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SAMUEL WENDELL WILLISTON
1852–1918

Our distinguished senior colleague in vertebrate paleontology passed away August 30, 1918, honored and beloved by all who knew him. He seldom spoke of himself, still less of the long struggles which beset his career. Our admiration for his character and attainments is enhanced through the perusal of his personal recollections,[1] which reveal a lofty spirit and an unfaltering determination. In the opening pages of his reminiscences he writes:

> As the oldest living student of vertebrate fossils in America and one of the oldest in the world, friends have urged me to write some of my recollections. Not that I am so very old, but because there were so few vertebrate paleontologists in the days when I first became interested in the subject—only Leidy, Cope, Marsh, and a few other lesser lights in America. Nor were there more than a dozen others in all the world, of whom Sir Richard Owen was the chief, who had published much about extinct vertebrates. It has never seemed to me that there was much of interest that I could say about myself, nor very much about the pioneers in paleontology that I could tell. I begin to feel that there are not many more years of work before me, and to regret that I have not accomplished more. . . . . But the way has often been hard, and I am thankful to be spared so long and to have done what I have.

And again, in closing:

> My life, as I look back on it, has had many discouragements and many pleasures. I have made many mistakes, as I now can see, and I have not

[1] See *Recollections*, an unpublished autobiography, written May, 1916, copyrighted by Mrs. S. W. Williston.

accomplished what I might have done. If I may extenuate my views I will say that for a country boy, with but little help and wholly without influence, the road to success is very hard. . . . . Perhaps for me experience was the best teacher, and an easy path in youth might have caused failure. But it was hard, and I have more than once been discouraged. I have drifted along somehow, with one underlying ambition, to *learn*. My plans and ambitions may seem fickle, first as an engineer, next as a physician, as a chemist, entomologist, paleontologist. I have tried various things, when one of them steadily pursued would have been better. In reality there was only one ambition—*to do research work in science*. And I have realized that ambition in a measure. I have published about 300 books and papers totaling about 4,000 pages. But the chief satisfaction that I find now in looking back over my life is that I have been the means, to some extent at least, of assisting not a few young men to success in medicine and in science.

Like all men of science who have risen to distinction, Williston was self-made, the impulses all coming from within; yet he was instinctively alert to seize every chance to learn and to expand his horizon. We cannot imagine a life-story more helpful than his to the youth predisposed to science who has both to discover his own talent and to explore every avenue of opportunity which presents itself.

Williston was born in Roxbury, now a part of Boston, July 10, 1852. "The Williston family," he writes, "has been traced back to about 1650 in Massachusetts; they were about the usual run of common people, no one famous or even noted, whether for good or evil. . . . . Some of them served in the War of the Revolution, and many were fishermen." His father was born in Maine, and he remarks of this branch of the family that "they knew little of schools. My father, if he ever went to school, did not take kindly to study, for he never learned to read or write. . . . . It was a great pity, too, for my father was a man of far more than ordinary ability as a mechanic—he was noted always for his skill. . . . . Of all his children I resembled him the most, both physically and mentally." His mother was from England, having come with her parents to New Jersey about 1812. She had a fair common-school education, and the effects of her early English training and her accent remained through life.

In the small garden attached to the little frame house in Roxbury began Williston's first studies in natural history, at the age of four:

My father had a little garden. He was planting potatoes one day with my aid, when several toads were unearthed. I was very curious to know where they came from, and he told me that they grew in the ground. I puzzled my childish brain about them and determined to raise a crop of them myself, so the next day I sedulously collected all the small toads I could find, in my little apron, and proceeded to plant them as I had seen my father plant potatoes. My father observed me and asked what I was doing. I told him I was planting them to see them grow. It caused him so much amusement that I went away crying to tell my mother about it. For years, until I was so old that I resented it, my father always called me "Toad."

The double point of this batrachian incident lies in its indication of an experimental mind, and in the coincidence that forty-one years later Williston succeeded Cope as one of the leading world-students of the extinct batrachian group.

The intellectual and social environment of Roxbury probably never would have produced a geologist or a paleontologist, and while the next step in Williston's life was hard, yet it was propitious, as the events proved:

In the spring of 1857 my parents decided to emigrate to Kansas. A colony had left the year before for Manhattan, and the letters that came back had infected many with the desire to go West. . . . . The abolitionists were urging eastern people to colonize the territory in order to help John Brown preserve it to the "Free States." . . . . The trip was long and tedious, by rail to St. Louis, then a small place, and thence by steamboat up the Missouri River to Leavenworth. There was no Kansas City then. We reached Leavenworth about the twentieth of May. Here we remained a few days in a very small hotel, while my father bought a yoke of oxen and a wagon and such provisions and household things as were indispensable, and we started on the slow and tedious drive of 115 miles to Manhattan through a country but very sparsely settled. For the most part we children rode in the covered wagon, while my father and cousin walked and drove the oxen. My mother was very homesick on the way. I can remember how long and bitterly she cried. One could not blame her; she now realized for the first time in this wilderness what she was leaving behind, perhaps forever. Nor did she see the East again for nearly thirty years, and my father never. We reached Manhattan June 7. The Emigrant Aid Society, under whose auspices this long journey was undertaken, provided a small log cabin, about 15 feet square inside, two and a half miles east of Manhattan, for our temporary use until a house could be built in the town itself. My memory of events is now becoming clearer. The house of our temporary occupation had but a single room with a loft reached by a ladder. There were two beds in the room below, screened off by cloth curtains that my mother soon found for them, and we

four boys slept in the loft. A big fireplace in one end, used for cooking, and a rough table and a few chairs comprised the furniture. I do not wonder that my mother was despondent, for there were no neighbors within two miles, and she needed courage, for the Potawatomie Indians had a village in the immediate vicinity, and the word Indian in the East was a synonym of savage. . . . . Like most Indians, they were thieves and unreliable, but I do not suppose we were in much danger for our lives. . . .

With these New England instincts, almost the first building erected in the village was a stone schoolhouse in the western part of town. It was of two stories, the first of which was never completed and served as a fine playhouse for the younger children. The second floor, in a single room twenty by thirty in size, was where my early education was obtained as far as algebra and McGuffey's fifth reader. My mother took the *Boston Free Flag*, a semi-literary paper, and there were a few books in the town the first winter I spent in it. Among other gifts of the Emigrant Aid Society to this colony was a small library of a few hundred volumes of more standard books, but I did not find a great deal in it to interest me. They were too mature for my childish comprehension. One only I recall, Stevens' *Antiquities of Central America*. I read it when I was about seven years old, and although I have not seen the work for many years I can still vividly visualize its many pictures of Aztec ruins in Yucatan. It directed my interest to Tschudi's *Peru* and Prescott's *Conquest of Mexico*, which a few years later made a deep impression on me and gave me that fondness for history which formed a large part of my reading for the next ten years. The Sunday-school libraries were soon exhausted, as I would take home every Sunday all that the teachers would permit. One only I can recall, Adoniram Judson's *History of His Missionary Experiences in Tahiti*.

Another incident of my seventh year stands out vividly in my recollections. Just north of Manhattan is Blue Mont, a steep and high bluff, the termination of a range of hills ending abruptly in the Blue River. In the sand bars of the river we boys often gathered clams, and I was surprised to find on the summit of Blue Mont shells which looked much like clamshells. I asked my father how they had got to the top of the bluff on the rocks, for all the clams I had seen lived in the water and could not crawl on land. He told me they had been left there by the great deluge which once covered all the earth. I took some of the shells to my Sunday-school teacher and she told me the same, and so Genesis acquired a new interest for me, and most of the verses I was required to memorize each week from the Bible were chosen from the Old Testament. My mother had prohibited us boys from going to Blue Mont and the river, for like most mothers she was afraid of the water, and not until I had surreptitiously learned to swim did she consent to let me go in swimming. Our favorite swimming-hole was among large stones filled with fossil shells of lower Permian age, and they were my first studies in paleontology. The old cottonwood house was too cold and inhospitable for our large family, and in 1859

my father built a better house about a quarter of a mile away. It was two full stories in height, and twenty by thirty, a large house then for the village. It was built chiefly of black walnut lumber, sawed by the little "Emigrant Aid" sawmill, and was long known as the "Black Walnut House." Its shingles and floors were of pine, brought up the Kaw River on a steamboat, one of the three that ever went so far up the river. I remember especially the boat, because its name in large letters spelled to me "Col-o-nel Something," and it worried me not a little that everyone persisted in calling it "Kernal." The pronunciation of the English language was a very mysterious and incomprehensible thing to me in those days.

We had been in this home but a very short time, not long enough to get settled, when there came up one evening one of those "cyclones" for which Kansas was long notorious. It threatened to blow down the house, and did destroy the house from which we had just moved, distributing some of its lumber quite into our back yard. . . . .

In 1860 my father bought the "Emigrant Aid Saw and Grist Mill." . . . . This was the year of the great drought, when practically no rain fell for fifteen months, and the crops were almost a total failure. Our subsistence for many months was almost exclusively corn meal and sorghum. There was no coffee except barley coffee, no tea, and no sugar. I have never been fond of corn bread since that time. When after more than a year my father obtained a sack of flour, the biscuits that my mother baked linger in my mind as the greatest delicacy and luxury of my life. . . . .

It was during this time that I got my second lesson in natural history. My father was very fond of fishing and hunting and went fishing every Sunday in the Blue River. Among the fishes that he brought home, chiefly catfish, shad, and buffalo, were river sturgeons. I usually helped him clean and prepare them for cooking. I observed that the sturgeons had no backbone like the other fishes, but instead, a long fibrous rod, the notochord. I puzzled greatly over it, but no one could give me any enlightenment. It was one of the things that later directed my interest to natural history.

Blue Mont College, founded by the Methodists in 1859, became merged into the State Agricultural College in 1864, and I was a very happy boy when in 1866 I was permitted to enter it.

Williston was now fourteen years of age, but it was not until a year later that he came under the influence of real scholarship and of a truly great work of science:

It was about this time, when I was fifteen years old, that Professor Mudge loaned me Lyell's *Antiquity of Man*. I remember the night I brought it home there was a dance at our house, in which I was not included, but it gave me the opportunity in an upstairs room to read the book until the guests departed in early daylight hours. I was thoroughly convinced, when conviction meant

antagonism to the church's teachings. Professor Mudge lectured about this time on evolution, to which he remained opposed until his death. It was my first introduction to the doctrine to which I soon after became a devoted disciple. . . . .

I was very fortunate in the character of my teachers, especially the teacher of science, Professor Mudge. I have published a brief sketch of his life and need not say more about him here. I doubt not that my life has been devoted to natural science chiefly because of his influence. I studied every study that he taught and they were many: natural philosophy, chemistry, botany, geology, zoölogy, veterinary science, mineralogy, surveying, spherical geometry, conic sections, calculus, etc. Mudge had a considerable collection of fossils and minerals that filled a long case. To me it was a wonderful museum. There were no laboratories of any kind, no microscopes, and but few instruments. The college catalogue of about that time, in enumerating its equipment, gravely mentions an electric machine, three Leyden jars, and six test tubes. The electric machine was a never-ending source of delight. The Professor occasionally got it out and charged the Leyden jars, and then, with hands joined in a circle, gave us a shock. He prophesied that some day electric light would take the place of other illuminations. My ambition was to make a machine myself, and I nearly succeeded, but I found no way of boring a hole through the glass plate for the shaft. The oxyhydrogen light was another great wonder. My greatest interest was given to physics, or natural philosophy as it was then called. I read every book on the subject that I could get in the library. Chemistry had second place, while biology interested me but little.

Williston left home at the age of seventeen, adventuring life first as a day laborer and then as a railroad engineer's assistant. He returned, however, to the Kansas Agricultural College and took the degree of B.S. in March, 1872. Once again he took up civil engineering, which he followed for a year. It was this profession that prepared him for his field work and for his subsequent observations in geology. It was in the spring of 1873 that he undertook the study of medicine in the office of his old family physician. Here he had free access to the doctor's library, and he at once turned to his initial studies in anatomy and physiology, which laid the foundation of his anatomical training and ultimately qualified him for a professorship in the medical school of Yale University.

In the meantime he had become an enthusiastic follower of the Darwinian doctrine, which was not at that time accepted as a demonstrated fact, and in February, 1874, he delivered in the local

Congregational church what he believed to have been the first public lecture in favor of evolution given west of the Mississippi River.

Quite by accident Williston accepted an invitation from a fellow-student to accompany him to northwestern Kansas (Smoky Hill Valley), where Professor Mudge, already famous through his discovery in 1872 of the specimen of *Ichthyornis*, was collecting. He writes:

> We left on the fifth [July, 1874]. *It was this accidental and thoughtless decision that led to my life's devotion to paleontology.* Had I not gone with him, in all probability I would today have been a practitioner of medicine somewhere in Kansas. We joined Mudge about the fourteenth and started almost immediately south. In a few days I found a good specimen of pterodactyl and became an enthusiastic lover of the sport of collecting fossils—for sport it seemed to me. I had planned that autumn to go East, if I could borrow a couple of hundred dollars, to attend a medical college. And so I returned to Manhattan by rail in September but did not succeed in getting the necessary funds. Mudge thereupon asked me to return, which I did about the first of October, and remained until we returned in November. . . . . For my season's work Mudge paid me $25, which bought me a suit of clothes and other things badly needed. My total cash income this year was not more than $50. It was the hardest year of my life. My board I worked for in part, in part I had it paid for by my parents, but I did not have a second whole shirt, and when I gave my address I had to borrow clothes to wear, for my clothes were ragged and patched.
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> Times now began to improve. Professor Marsh and Professor Cope, as is well known, were rivals and very jealous of each other. They had been quarreling with each other for two or three years, with mutual criminations and recriminations. Because of the discoveries Marsh was making in the Cretaceous of Kansas, Cope grew eager to participate in them but could find no one to undertake these collections, for Marsh was afraid to have too many learn about the region for fear that Cope would seduce some of the assistants by the offer of higher pay. He therefore instructed Mudge to retain his assistants of the previous summer. Brous and I were engaged for the following season at $35 a month and our expenses. We accepted the offer gladly and started for the field overland in early March, meeting Mudge at Ellis on the railroad. We stipulated that I should quit in September to allow medical lectures. . . . .
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> We collected chiefly along the Smoky Hill Valley that season, as far west as Fort Wallace, and got many valuable specimens. . . . . By Marsh's directions each had signed his name to the specimens he had collected. Perhaps that was the reason he invited me in February to come to New Haven. I

promptly accepted his invitation and sold my watch and borrowed enough to take me there in March. . . . . It was thus with feelings almost of awe that I met Professor Marsh for the first time at New Haven, Connecticut, on March 19 or 20, 1876. My heart was in my mouth when I knocked at the basement door of the old Treasury Building and heard the not very pleasant invitation to "come in." There was a frown on Marsh's face, accentuated by his nearsightedness, as he waited for me to state my business. No doubt he thought me a wild and woolly westerner in my military cloak, slouch hat, and cowboy boots, as I stammered my name. But he quickly made me feel more at ease. He found me quarters in a little building in the rear of Peabody Museum then approaching completion. The next day he set me at work studying bird skeletons with Owen's *Comparative Anatomy* as a guide. He was then deeply interested in his Odontornithes, and wanted newer specimens, especially of the smaller forms, which were very difficult to find in the Kansas chalk. For recreation I helped a few hours every day to carry trays of fossils to the museum.

Williston was now twenty-four years of age. Vertebrate paleontology had become his first love, but he had leanings toward human anatomy and medicine and entomology, first as an avocation and then as a vocation. He was afforded no independent opportunities for paleontological research and publication by Professor Marsh. In the summer seasons of 1876 and 1877 he collected with Professor Mudge in the Cretaceous chalk of Kansas. In 1877 he was sent by Professor Marsh to the Morrison, Canyon City, and Como quarries to co-operate with Professors Lakes and Mudge and Mr. Reed in taking out the types of *Atlantosaurus*, *Diplodocus*, and other sauropods. In Professor Marsh's laboratory Williston worked on the dinosaurs. In the field in 1878 he helped to collect the "Jurassic Mammals" and some of the smaller dinosaurs. For nine years (1876–85) he worked in Professor Marsh's laboratory, where he became closely associated with Marsh's other assistants, especially Harger and Baur, who influenced him greatly and for whom he had great admiration. He wrote a biographic note on Harger in 1887, which gives some interesting side lights on the relations of Professor Marsh to his assistants. In 1878 he published a brief communication on American Jurassic dinosaurs in the *Transactions* of the Kansas Academy of Sciences; but he had very little opportunity for further publication in vertebrate paleon-

tology as long as he was in New Haven. This led to the renewal of his medical studies.

While acting as assistant in paleontology he studied medicine at Yale, received the degree of M.D. in 1880, continued his post-graduate studies, and received the degree of Ph.D. at Yale in 1885. He then became demonstrator of anatomy (1885–86) and professor of anatomy (1886–90) at Yale and practiced medicine in New Haven, where he was health officer in 1888–90.

In 1886 he published some criticisms of Koken's work on *Ornithocheirus hilsensis* which give us some hint of his abiding interest in Kansas fossil reptiles, an interest which was soon to bring great results.

The turning-point in his scientific career, from anatomy and medicine to paleontology, came at the age of thirty-eight, when he returned to the University of Kansas as professor of geology. Kansas was the scene of his first inspiration in paleontology, and here his fossil studies and vigorous health marked the happiest period of his life. He taught both vertebrate and invertebrate paleontology, anatomy, and medicine, and several of his students have achieved distinction in these fields.[1] With respect to the breadth of his studies and of his influence at this time, his life was comparable only to that of Joseph Leidy, who, it will be recalled, was at once an anatomist, a physician, a paleontologist, and a microscopist of distinction. He soon began to publish studies on the Cretaceous reptiles of Kansas. Henceforth Kansas plesiosaurs and turtles, mosasaurs and pterodactyls, were the subjects of a long list of papers, mostly in the *Kansas University Quarterly*, from 1890 to 1899, with occasional articles on Kansas fossil mammals (*Platygonus*, *Aceratherium*, *Teleoceras fossiger*). Meanwhile he made many explorations of the Cretaceous of Kansas for fossil reptiles. At Kansas University Williston also kept up his two avocations of anatomy and dipterology; he served as professor of anatomy and dean of the medical school. He also continued to publish many papers on recent Diptera.

[1] Among these paleontologic students, who have since become known for their researches, were: E. C. Case, C. E. McClung, Roy L. Moodie, Herman Douthitt, Alban Stewart, Elmer S. Riggs, Barnum Brown, M. G. Mehl, and E. H. Sellards.

WORK ON THE DIPTERA

We may for a moment divert our attention to Williston's great work on the Diptera. At the Pittsburgh meeting of the Entomological Society of America in 1917 he gave many interesting reminiscences of his early work; he showed that he turned to the Diptera when he despaired of securing original material in vertebrate paleontology. It is seldom that science has seen talent so evenly divided between subjects so remote as dinosaurs and flies.

J. M. Aldrich, in his *Catalogue of North American Diptera* (Smithsonian Miscellaneous Collections, 1905), cites sixty-seven titles by Williston, covering the period from 1879 to 1899, and adds this note:

> An admirable feature of Williston's work, which does not show fairly in the above list, is the attention he has given to identifying and redescribing the species of other writers. In all his longer papers this is a prominent part, frequently occupying as much space as the new descriptions, and requiring more time than they in preparation.

This feature of Williston's work was, in fact, the result of his ever-active desire to be helpful—the same desire which prompted him to prepare his *Manual of North American Diptera*, a book which is indispensable to a beginner in dipterology and a very great convenience to advanced workers. It was this kindly, sympathetic spirit too which endeared him to his students and fellow-entomologists, while his accurate observations and keen judgment commanded respect everywhere.

Williston practically ceased active work on flies twenty years before his death, although his interest in them continued, as was shown by occasional papers, especially from 1906 to 1908 and again in the later years of his life. He jokingly said in conversation that he did not dare to think of flies lest he be tempted to take too much time from fossils. His collection of Diptera from the United States and Canada is now in the University of Kansas; the remainder of his collection, including much of the valuable material which he had collected while writing the volumes on Diptera in the *Biologia Centrali-Americana*, is in the American Museum of Natural History.

PALEONTOLOGIC WORK IN KANSAS[1]

Williston's paleontologic contributions on the Cretaceous fauna of Kansas began in 1879 with a short paper entitled "Are Birds Derived from Dinosaurs," and included fifty-three communications, chiefly to the Kansas Academy of Science, the *Kansas University Quarterly*, and the University Geological Survey of Kansas; also three volumes on the *Cretaceous Fishes* in co-operation with Alban Stewart; and *Paleontology* (*Upper Cretaceous*), Part I, Volume IV of the University Geological Survey, which was chiefly prepared by Williston with the assistance of his students Adams, Case, and McClung, and is a thorough review of the geology and marine fauna of the Cretaceous seas, containing the first clear distinctions and restorations of the great Kansas mosasaurs, *Clidastes*, *Platecarpus*, and *Tylosaurus*. This work became the standard for all subsequent researches of Osborn, Wieland, and others on the Cretaceous fauna. It contains some admirable restorations of mosasaurs and other fossils which may be compared with those of Dollo from the Maestrichtian of Belgium. The second part, Volume VI of the University Geological Survey, covering the Carboniferous and Cretaceous, published in 1900, included the Cretaceous fishes alluded to above, and the Carboniferous invertebrates by Joshua W. Beede.

In 1897 Williston published his first paper on Paleozoic tetrapods, a brief description of "A New Labyrinthodont from the Kansas Carboniferous"; his second was on the "Coraco-Scapula of Eryops Cope" in 1899; but nearly a decade elapsed before the Paleozoic reptiles and amphibians became his chief subject. From 1897 to 1902 he was engaged chiefly upon his series of papers on fossil vertebrates of Kansas for the University Geological Survey of Kansas.

Williston concluded his studies of the Cretaceous fauna during the early years of his professorship in Chicago, beginning in 1902. Thus his work on the Kansas Cretaceous fauna, following the very disjointed contributions of Leidy, Marsh, and Cope based on

[1] These notes on Williston's work on fossil reptiles and amphibians have been prepared in collaboration with Professor W. K. Gregory, of the American Museum of Natural History.

inferior material, marks the turning-point in this field to the new order of description and generalization based upon complete material, including even the skin impressions of several great mosasaurs. In his observations on the mosasaurs, plesiosaurs, pterodactyls and marine turtles, and the birds with teeth, Odontornithes, he placed the osteology of these several animals on a much more secure basis, adding a number of new generic types, such as a short-necked plesiosaur, *Dolichorhynchops osborni*.

His interpretation of function and habit is shown in his restorations of all these types, and his first observations on the feeding habits of the plesiosaurs and his more mature views on several of these animals were published during his sojourn in the University of Chicago, namely, "Relationships and Habits of the Mosasaurs," *Journal of Geology*, 1904; "North American Plesiosaurs," 1903, 1906, 1907. His first contribution to the phylogeny and classification of the Reptilia as a whole appeared in 1905 and was followed by his important discussion of this subject entitled "The Phylogeny and Classification of Reptiles," *Journal of Geology*, August, 1917. In this article, which expresses his mature opinions, he departed from his previous conservative attitude toward classification and proposed to add two subclasses of reptiles, the Anapsida and Parapsida, to the subclasses previously proposed by Osborn, namely the Synapsida and the Diapsida, making a fourfold grand division of the Reptilia. Doubtless it was Williston's intention to fortify this system of classification in his forthcoming general work on the Reptilia.

WORK ON PRIMITIVE AMPHIBIANS AND REPTILES[1]

In 1902, at the age of fifty, Williston was called to the University of Chicago as head of the new department of vertebrate paleontology, a chair which he occupied with great distinction and with continued influence for the remaining sixteen years of his life. He now began to concentrate his attention more exclusively on vertebrate paleontology. During the first six years he continued his studies and publications on the Cretaceous reptiles; then he began to turn toward the study of far more difficult and obscure problems, namely the relatively primitive amphibians and reptilian life of the

[1] See footnote, p. 683.

Permian, where in several groups he marked the beginnings of the higher forms which he had previously studied, as well as the adaptive radiation of the lower forms to a great variety of habits and habitats.

Professor E. C. Case, now of the University of Michigan, who was one of Williston's students at the University of Kansas, had co-operated with the late Professor Georg Baur at the University of Chicago in the study of *Dimetrodon* and other Permian reptiles and had collected for that University a number of important types of pelycosaurs and cotylosaurs. After Baur's untimely death Case continued to collect and study the Permian reptiles and amphibians of Texas and other states, finally issuing his well-known Carnegie Institution monographic revisions of the Pelycosauria and Cotylosauria, in which he revised and extended Cope's work on these animals and figured the types and other important specimens in the American Museum of Natural History, in the University of Chicago, and elsewhere. Thus Cope, Baur, Case, and Broili had opened and partly explored an important field of work which Williston had long desired to enter.

Accordingly in 1907 and 1908 Williston began to publish on this subject which occupied most of the closing decade of his life and constituted perhaps his greatest contribution to science. It is pleasant to record that Williston and Case at all times fully and cordially co-operated with each other in the study of Permian reptiles and amphibians. In 1908 he published an important but brief paper on the Cotylosauria, containing a description of the skeleton of *Labidosaurus incisivus*. In the same year Mr. Paul C. Miller, of the American Museum of Natural History, a collector and preparator of high rank, became Professor Williston's assistant at Chicago, and under his direction began a long series of explorations in the Texas Permian which have yielded results of the greatest importance to vertebrate morphology and paleontology. During the next decade these expeditions brought back to the University a great number of specimens, some of which will become more and more famous as their great importance is gradually realized. More or less complete skeletons were discovered, extricated with great skill, and admirably described in a long series of publications.

Among the more important of the new or little-known skeletons were the following, which, to students of the early evolution of the skeleton of vertebrates, will ever stand as important types:

Pariotichus laticeps, Williston
Trematops milleri, Williston
Aræoscelis gracilis, Williston
Seymouria baylorensis, Broili
Casea broilii, Williston
Mycterosaurus longiceps, Williston
Trimerorhachis insignis, Cope
Varanosaurus brevirostris, Williston
Ophiacodon mirus, Marsh

These were only the more conspicuous of the many priceless specimens which Williston and Miller have brought to light, and which the former has described and figured with the most painstaking care and accuracy. This material also enabled Williston to give definite and in many cases final figures of the sutural limits of the elements of the skull in most of these genera. Many investigators had attempted to do this from less extensive and complete material, but their results were often uncertain in detail and subject to important changes and corrections.

In 1911 he published from the University of Chicago Press his volume, *American Permian Vertebrates*, which comprises a series of monographic studies on some of the genera already noted. This work contains many new and original plates. Careful and extensive definitions are given of the orders Temnospondyla, Cotylosauria, Theromorpha, and of the included families and genera. In the same year, by invitation of Professor Schuchert, Williston examined and described the important collection of Permian reptiles which Mr. Baldwin had collected for Professor Marsh between 1877 and 1880, but which had never been thoroughly studied. Among other important results of this research was the erection of a new family of Cotylosaurs, the Limnoscelidæ, to include the skeleton of *Limnoscelis paludis* Williston. In 1912 he published, in collaboration with Professor Case, a paper on the "Permo-Carboniferous of Northern New Mexico," in the *Journal of Geology;* he also published a general review of primitive reptiles in the *Journal of Morphology*. In 1913 appeared a memoir in collaboration with Case and Mehl

on *Permo-Carboniferous Vertebrates from New Mexico*. The same year saw the publication of his important papers on the primitive structure of the mandible in amphibians and reptiles and on the skulls of *Arœoscelis* and *Casea*. The close resemblance of *Arœoscelis* to the Squamata especially in the temporal region was noted.

Early in 1914 came the publication on *Broiliellus*, one of Cope's "batrachian armadillos," and the fuller description of the osteology of *Arœoscelis*, with a discussion of the relationships of *Arœoscelis*, the Protorosauria, and the Squamata. He then referred *Arœoscelis* to the Protorosauria and placed this order next to the Squamata. In the same year he published a series of life-restorations of some American Permo-Carboniferous reptiles and amphibians.

His principal publication in 1914 was the book on *Water Reptiles of the Past and Present*, in which his life-work on these animals was admirably combined with the results obtained by other workers. Williston had shown a bent for the harmonious study of form and function, of structure and habit, of environment and adaptation, which he applied with skill and originality to the interpretation of the highly diversified forms of aquatic life. He followed Eberhard Fraas, of Stuttgart in making a special study of aquatic adaptations in the vertebrates; consequently his book on the water reptiles constitutes one of the most important contributions which we have upon this subject.

The year 1915 produced his papers on *Mycterosaurus*, a very interesting reptile, that threw light on the origin of the diapsid types, namely of reptiles with *two* arches at the side of the temporal region of the skull. Also on *Trimerorhachis*, perhaps the most archaic of the American Temnospondyls, or amphibia with the vertebrae composed of several pieces. In 1916 he published the careful description of the skull and skeleton of *Pantylus* and of *Theropleura*, together with the important discussion of the origin of the mammalian and reptilian types of sternum. This paper was followed by the admirable *Synopsis of the American Permo-Carboniferous Tetrapoda*, in which the principal types were illustrated, and careful definitions of the various groups were given. In 1917 he began a general work on the *Reptiles of the World, Recent and Fossil*, upon which he was actively engaged up to his

last illness; also the publication of his papers on *Edaphosaurus*, on the atlas-axis complex of reptiles, and, equally important, his brief paper on the "Phylogeny and Classification of Reptiles," previously mentioned. During the last two years of his life he was also preparing a paper on new Permian reptiles.

In summing up his life-work, "I like," says Doctor Gregory[1], "to emphasize the general features in which Williston was really preeminent, namely: (1) discovery of new material, Cretaceous Reptilia, Permian Tetrapoda, and Diptera; (2) conscientious and precise description of these; (3) eminently conservative synthesis of facts so as to work out a great and enduring record of Cretaceous and Permian reptiles; (4) intensive and successful specialization in several distinct lines of research and teaching.

It is a matter of the deepest regret to all of Williston's colleagues in paleontology that he did not live to complete his great comparative work on the Reptilia, which would have summed up all his researches and observations and the facts stored in his mind which have never found their way into print. As an investigator he combined in an exceptional degree anatomic accuracy in detail with breadth of vision and power of analysis. His associates in the special field of Permian research considered his opinion as a homologist weighty. A committee was formed, chiefly composed of Americans, of which Williston was senior, to endeavor to establish the difficult and intricate questions of homology and to base upon this an enduring terminology to replace the confusing whirlpool of names for certain skull bones which have accumulated since the time of Cuvier.

A few of the more general features of Williston's life-work and character are as follows: He strove arduously through forty years of investigation to discover new material in the field and to widen our basis of facts in several distinct lines of investigation; he preferred to discover new facts rather than to reinterpret older ones or to adjust the interrelations of facts; in general, his material was notably of his own finding. Nevertheless, especially in his late years, he labored very successfully to classify and synthetize his material, and with it that which had been treated by other workers.

[1] See footnote, p. 683.

Here his genial personal character and admirable relations with his colleagues shone forth; he was singularly appreciative of the work of other men and ready to adopt whatever he believed to be solid and enduring in previous attempts at classification. Thus Williston's work stands in contrast with that of Cope and Marsh, whose personal differences of opinion led to the setting up of two entirely distinct systems of classification as well as of nomenclature, irrespective both of priority and of merit.

Williston's keen, broad knowledge of human anatomy, of the muscles as well as of the bones, doubtless aided his penetrating insight into the habits of the extinct animals, and while generally conservative and cautious his phylogenetic studies and suggestions were of high value. His views on taxonomic standards[1] and upon college and high-school education[2] were, like his views upon paleontologic problems, characteristically sober, moderate, and well considered, lighted up in their expression with his genial, half-humorous manner. He was ready to confess and appraise defects or faults on his own side, but quick to resent exaggerated accusations and criticisms from the other side.

The closing years of Doctor Williston's life were clouded by illness and the sorrow of losing a much-beloved daughter. He was a devoted husband and father. His friends and colleagues met him last at the Pittsburgh meeting of the Paleontological Society of America, December 30, 1917, and enjoyed a few of his short and characteristically enthusiastic communications and discussions. With Doctor Holland, myself, and many other warm friends he stayed the Old Year out and saw the New Year in at the Society smoker. He returned home quite suddenly, and this was the last occasion on which we enjoyed his genial presence, his humorous narratives, and his inspiring influence in paleontology.

HENRY FAIRFIELD OSBORN

AMERICAN MUSEUM OF NATURAL HISTORY
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[1] "What Is a Species," *Amer. Nat.*, XLII, 184–94.

[2] "Has the American College Failed to Fulfil Its Function?" *Proc. Nat. Educ. Assn.* (1909), p. 526.

CHARLES RICHARD VAN HISE
1857–1918

My first impressions of Van Hise were received from the gifted and lamented Irving, when we were close colleagues on the Wisconsin Geological Survey, and when young Van Hise was a student of geology and related sciences under Irving at the University of Wisconsin. Only those who had the good fortune to taste the rare flavor of the brusque humor of Irving can appreciate how charmingly he brought out the traits of his promising pupil as he told of their good-humored laboratory bouts over problems in hand. These little tales of the laboratory come back to me now as precious reminiscences at once of the trainer and the trained; as also of the crude state of petrological technique with which they had to struggle. It was just at the time when the polarizing microscope was coming into use in America in the examination of thin slices of crystalline rocks, and when only a few of the better-trained and bolder young men were venturing to try the new art. Young Van Hise, working under Irving on the crystalline rocks of central Wisconsin, came to think that he had discovered a new characteristic of a certain constituent under study and became sanguine that it would prove distinctive and constitute a contribution of some notable value at that early stage of the new art. He was naturally elated and confident, but Irving, playing the part of the conservative and critical trainer, kept the young enthusiast's elation in curb by all sorts of objections, real and fanciful, and made light of the arguments he urged in support of his claims; but Van Hise held his ground sturdily and returned undauntedly to his lathe and his microscope to search out new evidences and to strengthen old ones until, in due time, he made good against all the probings and humorous pooh-poohings of his instructor.

This earliest picture of Van Hise's sturdiness of mind and invincible industry—reaffirmed as it has been so often in our long, intimate acquaintance since—has always seemed to me to portray

one of the most salient traits of his strong personality. He always seemed to realize that one must dig to discover, and that after he had brought forth his results and built them into a logical structure there would still be winds that would blow and storms that would beat and that, as a matter of course, the world would always be probing and pooh-poohing whatever he advanced, and so it was for him to lay the foundations so well and to brace the parts so firmly that the structure could meet the stress sure to be brought to bear upon it. Thus too he seemed quite willing to have his products go to the test and quite ready to accept the issue. This intellectual sturdiness and steadfastness, abetted by an instinctive adherence to purpose, stand out as conspicuous traits in the whole career of President Van Hise.

When he, in his turn, became an instructor, he repaid his debt to Irving by inspiring a gifted student of his own, young C. K. Leith, who in after years became his own close companion and co-worker. These three names, Roland Duer Irving, Charles Richard Van Hise, and Charles Kenneth Leith, will always stand together in the geology of the central crystalline area of our continent as a scientific triumvirate. Their great work is so intertwined that no one may completely separate it. Of this gifted trio Van Hise formed the middle bond.

The dominant qualities we have noted appear in quite another form; there was geographic persistence and centralization. It is a rather notable fact that from birth to death Van Hise's great activities, notwithstanding their breadth, clustered about his early home and centered in his native state. He was born at Fulton, Wisconsin, not thirty miles from his final resting place at Madison. His higher educational career began and ended at the University of his native state, to whose greatness he largely contributed. His scientific researches started with studies on the ancient rocks that form the nucleus of "Isle Wisconsin," and he seems ever to have come back to its symmetrical structure as a geologic standard. His public service, broad as humanity though it was, had its center and spring in the higher welfare of the people of Wisconsin and of the great commonwealth to which it belongs.

The academic career of Van Hise was a steady ascent; he passed upward easily and naturally from student in mechanical engineering, 1875–79, to instructor in metallurgy, 1879–83; thence to assistant professor, 1883–86; to professor, 1886–88; to professor of mineralogy, 1888–90; to professor of Archaean and applied geology, 1890–1903; and thence to the presidency of his Alma Mater in 1903, which he held until his death in 1918. He gave collateral academic service at the University of Chicago as non-resident professor of structural geology from 1890 to 1903.

His scientific career was a similar ascent from state and interstate relations to national and international relations. His early scientific work was connected with the State Geological Survey of Wisconsin and related to the crystalline formations of the central and northern part of the state, particularly the iron- and copper-bearing series. At the close of the State Survey these studies were transferred without interruption to the United States Survey and were steadily broadened to include other regions. He worked in close association with Irving until the latter's untimely death in 1890, when he succeeded to the direction of their common governmental work on the pre-Cambrian formations in the Lake Superior region and elsewhere.

The investigation of the crystalline rocks of the Basement Complex was the chief geologic task chosen by Dr. Van Hise. It is needless to say that it was pursued with characteristic ardor and enthusiasm until he was called to the presidency of the University of Wisconsin in 1903. The chief results of these geologic investigations appear in a series of large monographic volumes that stand as a monument of persistent industry and commanding ability. The more important of these are: *The Penokee Iron Bearing Rocks of Michigan and Wisconsin* (1892) [with Roland Duer Irving]; *The Marquette Iron Bearing District of Michigan* (1897) [with W. S. Bayley and H. L. Smyth]; *The Menomonee Iron Bearing District of Michigan; Geology of the Lake Superior Region* (1911) [with Charles Kenneth Leith]; *The Archean and the Algonkian* (1892); *Principles of North American Pre-Cambrian Geology* (1896) [Appendix by Leander Miller Hoskins]; "Some Principles Governing the Deposition of Ores," *Journal of Geology* (1900); *A Treatise on Metamorphism*

(1904). To these major treatises are to be added many contributions to scientific periodicals and to scientific societies, as well as addresses and minor papers of other types.

These monumental studies made Van Hise *facile princeps* in the great field of pre-Cambrian geology. His work is too broad and complex for analysis here, but it may be said to rise into two climaxes, the first structural in nature and best expressed in the generalizations of his *Principles of Pre-Cambrian Geology*, the other chemico-physical and best set forth in his *Treatise on Metamorphism*. No treatment of either of these almost illimitable themes could in his day, or in our day, or in the near future, be the last word on these intricate subjects, but the contributions of Van Hise must always be regarded as marking a great epoch in the progress of the geology of the earliest terranes.

It was one of the cherished ambitions of Dr. Van Hise to reduce the complex phenomena of early crystalline geology to the principles of chemistry and physics. His effort to do this appears in clearest terms in his *Treatise on Metamorphism*, but it also runs as a strong vein through most of his later geologic writings. His generalizations respecting metamorphic processes are perhaps to be regarded as his broadest studies and as his climacteric contribution to geological science.

In attempting now to summarize his work we must not fail to observe that just as some of the fruitful work of Irving came over by inevitable inheritance into Van Hise's work and enriched it, so some of Van Hise's work has passed over into the still evolving work of Leith and lives in it and will perhaps prove to have some of its best fruits in it as it gradually evolves We must at least note that the fruitage of Van Hise's planting is still growing and ripening.

In the very nature of the case, work on the great iron- and copper-bearing formations of the Lake Superior region always gave a notable economic bearing to the studies of Dr. Van Hise, and so, as his mind always sought principles and generalizations as the most vital embodiment of specific facts, he was naturally led to draw important conclusions relative to the principles of ore deposition, particularly those connected with secondary

concentration. These are perhaps summarized best in his address as retiring president of the American Association for the Advancement of Science, delivered at Denver in 1901.

With his acceptance of the presidency of the University of Wisconsin, Dr. Van Hise made a serious and at first confident effort to continue his geological researches in addition to his administrative duties, but he soon became so deeply engrossed in the humanistic phases of his new work that there was little time left for effective research in the old lines, and so his foremost interest shifted to the new work. The two interests, however, merged, in a measure, in his study of the application of natural resources to the general welfare of man, especially the conservation of natural resources, to which he made several notable contributions, among them the best book on the subject.

It was natural to pass from this special line of economic study to the broader aspects of current commercial and industrial questions, where his chief interest seems soon to have centered on the organization and co-ordination of effort as the key to the solution of the vexed questions that agitate this field. Most notable among his writings in this line perhaps is his book *Concentration and Control, a Solution of the Trust Problem in the United States.*

The utter breakdown of the basis on which the leading industrial legislation of the United States had been based, as soon as the stress of the Great War forced the nation itself to become a vast industrial institution, and the precipitate resort of the nation to practices diametrically opposed to those embodied in its previous legislation, deeply interested President Van Hise and obviously rendered his previous views on co-operation and co-ordination still more definite and strong. At any rate, these views were urged with still more vigor in his last years and formed the keynote of his book *Conservation and Regulation in the United States during the War.*

President Van Hise was profoundly interested in the war and made its probable intellectual, ethical, and economic outcome a special subject of study. As an administrator he vigorously marshaled the resources of the institution over which he presided in support of a strenuous prosecution of the war, while personally he contributed directly to it by lectures, papers, and other service

of notable value. His most conspicuous service was the aid he rendered in the conservation and allocation of our food resources. As the war drew to a close he became especially interested in the formation of a League of Nations. He prepared an address on this subject in which, with his ever-present regard for the practical and the attainable, he drew with greater definiteness than most other advocates the features which such a league should, in his judgment, embody. This was essentially his last contribution to the public welfare.

As the administrator of a great educational institution he naturally regarded science as the bed rock on which educational practice should be based, but he did not interpret science in any narrow or technical sense; he viewed it broadly as an expression of the carefully sifted and thoroughly proved reality disclosed in each and every field of inquiry. Research as an indispensable condition for discovering, demonstrating, and enlarging the body of science, as also for rescrutinizing and renovating that which had previously passed for science, he held absolutely essential to a true university. He went farther and regarded it as essential also to education in all grades; for the renovation, the reconstruction, and the reshaping of the subject-matter taught in all the grades he held scarcely less vital to primary education and the public welfare than the addition of new subject-matter on the frontiers of knowledge. Important as he held original research to be, however, he held its application to the affairs of life and its incorporation into the lives of citizens as a working, guiding, inspiring factor to be an equally important function and an equally imperative obligation of a state institution. He was fortunate in coming into the presidency of an institution whose working lines were already set in the directions he approved. With this inherited advantage he pushed the university forward in its adopted lines with great success.

Respecting the debatable borderland between what is to be regarded as a permissible function of a state university, on the one hand, and what is to be regarded as non-permissible, or scarcely permissible—particularly in matters where organized bodies of citizens differ—on the other, President Van Hise was rather strongly

predisposed to magnify the former. He placed a distinctly broad interpretation on the functions of the university. He thought it not only the privilege but the duty of the university to give the state leadership even in lines regarded by some others as at least debatable While this view did not go so far as to include the precise matters that divided the organized political parties, it yet did embrace matters closely akin to these, matters felt by some others to fall within the outer borders of party policy. The more conservative policy of leaving a clear margin of safety between the conceded fields of scientific inquiry in such matters, on the one hand—in which all right-minded citizens should concur—and the fields of party conflict, on the other, seemed to him to fall short of the full duty of the university to the state. As a natural result of his vigorous advocacy of some policies held by others as debatable, friction of the milder sort arose at times and made the path of his administration less smooth than it might have been under the more conservative policy, but this never went so far as to loosen the great hold of the institution or of its president on the affections and pride of the people of the state. His administration of the university was a declared success; both he and the university under his care exercised a profound influence on the intellectual and material progress of the state.

From May 29, 1857, to November 19, 1918, was the span of a remarkably fruitful career. It was, we grieve to note, two decades short of the full period of fruitfulness we had ground to hope for, but the vigor and intensity of the work, its solid nature, and its effective usefulness made good, in some large degree at least, the shortage in time. President Van Hise's contribution to the world has been very large and very rich.

His home life was singularly happy, though shadowed in his last years by the death of a beloved daughter. He leaves a devoted wife and two affectionate daughters. His personal qualities were of the highest order. He was a congenial companion in the office, the laboratory, and the field. His point of view was large and liberal, always incisive, often humorous. His convictions were strong, and the courage of his convictions never seemed to fail him.

was outspoken and manly in bearing, frank and strong in his

friendships. He respected the sincere, and called forth sincere respect in return.

He received a due measure of the honors his work merited. Williams, Dartmouth, Chicago, Yale, and Harvard conferred upon him their highest honorary degree. A long list of scientific societies in this country and abroad honored themselves and him with membership. He was chosen to the presidency of practically all the scientific societies to which he could be regarded as naturally eligible.

THOMAS CHROWDER CHAMBERLIN

HENRY SHALER WILLIAMS
1847–1918

Professor Henry Shaler Williams died in Havana, Cuba, on July 31, 1918, at the age of seventy-one years. During his lifetime he had been one of the leaders in his profession and was a pioneer in the modern practice of studying fossil faunas as units for investigation, as contrasted with the practice of collecting and describing fossil species.

Professor Williams spent his college days at Yale, where he graduated in 1868. His interest in natural science led him to continue his studies as a graduate student, a rather unusual practice in those days, and he was granted the Ph.D. degree in 1871. The following year he held the position of professor of natural history in the University of Kentucky, after which time a break occurred in his scientific career. For eight years he was engaged in business with his father and brothers, in Ithaca, New York, but during this whole period his real interest was in natural science, and he never gave up the idea of devoting his life to the pursuit of science.

Although his early scientific work in Yale had been in zoölogy, and he had made some contributions to the literature of that subject before 1872, when he returned to scientific work in 1880 he entered the faculty of geology in Cornell University. His earlier zoölogical interests naturally directed his geological work toward the field of paleontology, and he entered his new field of activity with the point of view of a man of science rather than as a professional geologist. His lack of close association with scientific work during the period immediately preceding his connection with the Cornell faculty led him to enter his new work with an independent attitude of mind, which is perhaps responsible, in part at least, for his early pioneer work. He at once set about the search for problems to solve, and he found them in plenty right at home. His own experience during those early days at Cornell led him to advise his students always to search for and solve the problems that were

to be found in their own dooryards rather than to think that any problem worth solution must be sought for in distant parts of the earth. His exceedingly careful investigation of the geological section at Ithaca, with the careful collection of fossils from bed to bed and the study of their associations in faunas and faunules, and his observations upon the geologic range of species and their recurrence at different horizons in the section really brought to the attention of students of fossils a new field for research and new problems whose relations to the problems of the stratigraphic geologist were much more intimate than the mere search for and naming of new fossil species.

For a number of years he continued his studies of the fossil faunas of the Devonian in central New York, making careful comparisons between the faunal succession as he had found it at Ithaca and the succession in other sections farther west, which represented the same time interval. The results of these very careful observations upon the faunas and their stratigraphic relations led to his proposal of the doctrine of "shifting faunas" within the limits of a single basin, the movements of the various faunal associations being governed by changing environmental conditions. All these studies led him more and more to the consideration in its broader aspects of the succession of life forms upon the earth, and directed his studies into the field of organic evolution as exemplified by the actual geological history of organisms.

The unique character of Professor Williams' investigations of the Devonian faunas of central New York early called attention to his studies and led to his selection as director of the Devonian work of the United States Geological Survey, to which was also added the direction of the work upon the Carboniferous. His survey connection made it possible for him to extend his studies into broader fields but did not lead to the severing of his university ties. Among other problems his survey work led him to the study of the Devonian faunas of Maine, and his latest contributions to the literature of paleontology have had to do with the Devonian and Silurian fossils of that state.

In 1892 Professor Williams left Cornell University to become Sillman professor of geology in Yale University, where he succeeded

Professor James D. Dana. He remained in this position for twelve years, when he returned to Cornell and continued his work there until his retirement as emeritus professor of geology in 1912.

Professor Williams' name will always be associated with the development of American paleontology and more especially with the American Devonian. His more philosophical contributions, however, are applicable to the life of all periods.

As a teacher Professor Williams exercised a great influence in the encouragement of his students in research. He did not believe in directing each separate step which his pupils took, but he believed rather in leading them to search for their own problems and when found to solve them independently if possible. He considered the field of scientific paleontology to be limited in its possibilities for a livelihood, and consequently he never offered undue encouragement to prospective students to enter the work. To those who were bound to enter, however, he gave the best council and advice of which he was capable. He was especially a laboratory teacher, and he made his students feel that they were companions with him in research. He was a man of most amiable disposition and spirit, and his kindly smile could never fail to reach one's heart. He was a loyal friend and always rejoiced in the success of those who had come under his instruction.

STUART WELLER

WORLD-ORGANIZATION AFTER THE WORLD-WAR—AN OMNINATIONAL CONFEDERATION

T. C. CHAMBERLIN
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It seems quite needless to say that the world-war now in its closing stages forms a crucial epoch in world-history, that its origin was closely linked with events running far back into the past, or that the outcome will vitally condition the future. It seems no less needless to say that the whole history of the earth, in its broadest sense and in its utmost reaches, has been closely linked as a co-ordinated series of events and will remain so linked far into the future; or that the material factors in this world-history are intimately intertwined with those that condition life as well as mental and moral issues. And so all episodes in world-events, however special they may seem on the surface, are to be viewed as factors of a co-ordinated unit in which each event plays its part in the composite whole.

And yet with little doubt every reader, at first flush of thought, will feel a touch of surprise that a discussion of world-organization after a world-war is given a place in a magazine devoted to earth-science, however broadly that periodical may try to cultivate its field. But in the face of this, and with due deliberation, a medium has been chosen in which discussions of former crucial stages of earth-history are wont to appear and a scientific atmosphere habitually invoked to control the spirit, the purpose, and the method of discussion.

The European balance of power and the European concert as peace devices.—Before the war, the control of international affairs in Europe was sought by means of a "balance of power," with a Triple Alliance in one pan of the scales and the Entente Powers in the other. The periodic disturbances of this balance and the recurring threats of discord in the "concert of powers" left the way open for sinister underplays; a series of wars arose in spite

of the efforts to keep the peace, and these wars led up to the recent gigantic conflict. So this equilibrium scheme for the preservation of peace must take its place among the list of futile efforts. The way in which the balance was disturbed reveals the point of danger in all such schemes. Almost at the opening of the war the Triple Alliance fell apart and was soon replaced by the "four-in-a-row" combination so significantly strung on the Berlin-Bagdad line, while the Entente group became a center of accessions and gradually grew into the "associated nations" that have just triumphed in the military stage of the struggle. As the inevitable result of such radical shifts of alliance, confidence in the reliability of alliances as a guaranty of peace is greatly weakened. The thoughtful world is therefore casting about to find some other form of organization that gives promise of controlling world-affairs more successfully.

The proposed League of Nations.—In lieu of a balance between alliances, a single league of nations, so strong and so inclusive as to dominate the world, is the favorite scheme of the hour. The factors that are to unite to form this proposed league are still, as before, the several nations, and these nations are to carry into the compact, as before, all their diversities of nature and interest. These diversities give reason to question the endurance of the new league when new lines of stress shall arise. All past leagues have given way in time; why should not this? But what other course is possible? What but the nations as they happen to be can enter into compact to preserve the peace? Can the diversities be set aside and the nations unite on a common homogeneous basis? This is the soul of the proposal here submitted.

The elements of a homogeneous basis.—It seems altogether practicable to divide the interests of the nations into two quite different classes, the first to embrace inherent rights shared alike by all, such as appropriate conditions of self-determination, of self-development, of intercourse with the rest of the world; the second class to embrace such more special interests as spring from the individual natures, inheritances, or peculiar preferences of each nation, those for example that grow out of the affinities of race, language, religion, modes of life, social ideals, and trade preferences. The first class

of interests are necessary to the normal existence and development of a nation, and by reason of this are stable and essentially irreversible; the second, to a notable extent, are merely preferential and naturally are subject to change and even to reversal with alteration of conditions.

Because of these radical differences there is reason to believe that all right-minded nations can be brought to support with constancy and fidelity such measures as may be found necessary to establish and to maintain a common control of the first class of interests, because these are as indispensable to their own welfare as to the common welfare, while they might take diverse attitudes in relation to measures intended to promote some aspects of the interests of the second class. Even if they united on these under given conditions, they might separate with change of conditions.

A further separation of the fit from the unfit interests is necessary for a practical working scheme. Only those interests that are tangible, measurable in physical units, and registrable in definite terms are well suited to successful administration.

Just how these essential qualities may be combined in a working scheme will appear a little later. Just here let us hasten to note that there is no antagonism or incompatability between a new omninational organization based on common interests and inherent rights and a new league of nations based on special national interests; on the contrary, the placing of common interests and inherent rights under an omninational body created for the purpose leaves the remaining interests for national alliances based on the affinities and preferences of the nations concerned. The adoption of an omninational scheme contemplates supplementary leagues of a more special sort as its inevitable complement.

The peculiar fitness of the existing league of nations for the settlement of the war issues.—The war issues are now in the hands of a league born of the stress of war conditions. As the product of these special stress conditions, it fits the requirements of the war settlement to a supreme degree; it was born to meet them. This war-born league has already won in the military contest; it is more likely than any other possible league to meet the requirements in

statesmanship that are now imminent. Without essential addition or modification, the "associated nations" constitute a league supremely fitted to bring to a close the present issue, to guide in reorganization, and to hand the conduct of world-affairs over to new organizations born of the new peace conditions and fitted by such birth to insure a great era of peace in the future. In its military and material power, in its collective intellectual prowess, in its indomitable purpose, and in its moral fitness, this war-born association of nations cannot be greatly strengthened by any accessions now available, while it might be much hampered by such accessions. It could scarcely be strengthened by the addition of peoples who have been idle bystanders or equivocal onlookers during the great conflict. It could scarcely be strengthened by the addition of the little neutral powers, so unfortunately located on the borders of the aggressive empires that they have been forced, willingly or unwillingly, to be the avenues of supply for the aggressive forces. It could gain little power or fitness for its function by additions from the Russian empire, once a co-ally, whose dissolution has given rise to half-formed republics on the one side, and on the other to an autocratic oligarchy more deplorable than the autocracy from which it sprang. The war-born league of associated nations, in the form in which the stress of war brought it into being, is itself the most fitting league to guide and control the great interests of mankind until it shall have achieved the more complete triumph that remains to be won through a wise settlement. For the immediate future, therefore, it is in the highest interests of mankind that events should take shape under the leadings of the league that has brought us to this first stage of triumph.

The punitive war function versus the requisite impartial peace function.—Supremely fitted as the war-born league is for the settlement of the immediate issues of the war, it is not altogether well suited to be the immediate instrument in building up a spirit of peace. The war issue cannot be settled either in justice or in wisdom without due punishment for the unlawful deeds of the war. The security of the future demands that the guilty be adequately punished. The war-born league cannot therefore divest itself of the memories of the war or of the punitive measures that must

follow. The animosities engendered in the war and in its settlement are likely to linger for three or four generations at least. The "associated nations" must continue to stand sponsor for the complete fulfilment of the reparations it decrees and it cannot escape, and ought not to wish to escape, the associations that cling about the dispenser of justice.

On the other hand, the body that is to develop a permeating and profound disposition toward peace should be as impartial as an inorganic law. It is one of the special features of the proposal herein offered to create a body whose actions shall be as nearly impartial as possible by resting them on a foundation of which parity is the cornerstone. The punitive function of the war-born league stands in contrast with the impartial function needed in the new organization which is to develop a lasting spirit of peace. It is therefore believed to be best that the punitive function be carried into effect by the "associated nations," while the impartial functions looking toward lasting peace be committed to a newly formed body whose constitution shall equally fit it for its special function. It is quite obvious that the punitive action should be taken as promptly as practicable and be carried steadily and firmly into effect until its terms are fully satisfied, or at least fully assured of satisfaction. It seems almost as obvious that this punitive work should be done and out of the way, so far as practicable, before the impartial régime for the development of the peace spirit shall be instituted. This does not mean that all penalties should be actually satisfied in full, but merely that they should be adjudicated and the satisfaction guaranteed. These vital considerations seem to point out, not only the nature of the bodies best fitted for these two functions, but also the order of their actions.

The settlement of the immediate war issues a necessary step toward new organization.—There should be no illusion respecting the present status of the great issue. The triumph of higher ideals has indeed been begun and begun auspiciously, but it is far from complete. The military victory is great, but victories in statesmanship no less great are necessary to make the ultimate issue really triumphant. Certain steps toward settlement obviously need to be taken at

once; others, if wisely taken, must necessarily be delayed. Time is imperatively demanded for the processes of reorganization. Four dynastic empires have fallen into chaos. At their best they were little more than forced agglomerations; they were not true nations. They were formed of diverse and discordant materials bound together by dynastic force, not by spontaneous coherence. Some of the people thus agglomerated were held in hated relations by a duress little short of slavery, though they were worthy of an honored place among nations. The gallant Czecho-Slovaks have shown their worthiness in a heroic, not to say dramatic, way. The crumbling of these agglomerates leaves a chaos of distraught peoples, some of whom are worthy material for reorganization, others of whom are but the morbid products of unwholesome conditions. These morbid products are the greatest threat of the crisis as it stands today, a greater threat, indeed, in some respects than the dynasties from which they have sprung. Like an eruptive fever, this sinister offspring of autocracy has broken out on the surface and shown its full malignity, the better to point the need of treatment. The disease is likely to run its course, but the danger of contagion calls for firm and wise treatment. The war-born alliance of nations is the appointed power to deal with this diseased state and to rescue the wholesome factors of the defunct empires from its deadly ravages. The call to this function is imperative and immediate.

A period of national reconstruction necessary.—When this deadly fever shall have burned out the morbid inheritance from the defunct empires, the worthy elements that remain will need time and aid in segregating themselves according to the natural laws of national evolution, as also in assuming the conditions of normal national life and in entering upon the functions of true nationality, before they can wisely become parties to the final settlement. The task of the associated nations in this process of national reconstruction is likely to lie in at least four lines—the preservation of order, the establishment of stable governments, the arbitration of contests respecting boundaries, and at least preliminary provision for outlets and inlets. The last two functions raise issues that must run on into the far future and should be influential factors in giving shape

to the organization later to be instituted in the interests of permanent peace.

This indispensable interval for segregation and reorganization into new nationalities may perhaps be placed at three to five years; the delay may be a sore trial to the impatient, but it seems imperative to safe procedure.

A further test of the principle of allocation of resources.—During this period of reorganization, and in the performance of the obligations which have been thrown upon the associated nations by their triumph, they will almost inevitably carry forward the present experiment in the control and apportionment of the resources of the several nations that make up the league. This allocation of resources is, in the minds of some of the most thoughtful students of the issue, regarded as the central working idea of the proposed league of nations. It is apparently not so in the minds of others. The control and apportionment of resources has been a most vital feature in the workings of the association of nations while it has been winning the war. The pressing needs of the impoverished and starving peoples of Europe will make a continuation of this allocation indispensable for some time to come. During the stress of the war, the conditions under which the control and distribution of food and other resources have been tried were quite exceptional, and it is by no means clear to what extent even the most right-minded peoples will be willing to submit to the deprivations that have attended this system, when the stress of war and the call to sacrifice are gone. But as the war conditions pass away and peace conditions return, the application of the system may be tested in a more nearly normal way. The allocation of resources is no part of the scheme herein proposed but may be a consideration in forming supplementary leagues. It is applicable to that class of international interests that we have put in the second class because they relate to the *diversities* of national interest rather than the common interests on which the proposed omninational organization is to be based.

The new nationalities to be considered.—One of the first steps looking toward lasting peace is the development of normal nationalities out of the autocratic agglomerates. The factors that

constitute normal nationality are not only complex but they vary in value in different cases. As a result no *simple* definition is possible, nor will any *single* definition suffice. Each nationality carries its own special combination of characteristics, which vary with the value of the several factors that enter into it. And yet in each concrete case presented it is usually possible to form a fairly just opinion of what peoples should form separate nations. But even then the border lines between such nations are often extremely difficult to fix, because there is more or less of mixture of diverse peoples and patchy inter-distribution. The only practicable mode of procedure seems to lie in fixing the bounds as well as may be and letting time bring about a better accommodation.

It is fairly clear that the Polish people, the Czecho-Slovaks, the Jugo-Slavs, the Anatolians, the Armenians, the Syrians, the Palestinians, the Arabians, and the Mesopotamians should be seriously considered as candidates for organization into independent nationalities, but their claims vary much, both in kind and degree. So, also, it seems clear that the provinces wrested from France by force should be returned to her, that the provinces taken from Italy should be returned to her, that the Rumanians should form a single nation, and that various rectifications of bounds are needed in the Near East, while some rectifications of border lines of Belgium, Holland, and Denmark are desirable, if they can be agreed upon. The grave question whether a single new nation or a group of related nations shall emerge from the chaos of the great empire of Russia is as yet too much beclouded by uncertain conditions to warrant discussion, but it obviously constitutes an imminent problem of the future.

The problems presented by these candidates for recognition as independent nations are already taking shape and will find preliminary settlement in connection with the other war issues, and so the specific proposals of this paper are offered on the assumption that most of these peoples will have organized themselves into true nationalities and will have been recognized as such by the associated nations before the proposed general confederation shall be formed. The lines on the accompanying map are drawn on the assumption that the peoples named will form independent nations. If these

lines are not those which shall ultimately be established, the principles they are intended to represent will still remain applicable to whatever lines shall obtain.

THE BASIS OF THE NEW ORGANIZATION

World affairs center about international intercourse. The exchange of products is its most tangible phase. Some of these products are material, others mental or moral, but only the material products are measurable in definite terms, and so these only are well suited to be the basis of a concrete working scheme. As a rule mental and moral factors run apace with the material, but this is not always closely and accurately so. And yet the material exchanges form a fairly just representation of the whole intercourse. Commercial exchange is therefore made the basis of the scheme of omninational conduct of world-affairs herewith offered. It has two obvious factors: (1) provision for intercourse, and (2) equitable administration of such provision in the interests of all peoples. The ethical ideas at the bottom of the proposals may be expressed concretely as follows:

A. *Fair opportunities for commercial and other intercourse between all peoples under such reasonable economic regulations as they themselves may impose.*

B. *Protection and regulation of international intercourse by an omninational body representative of all peoples in proportion to their participation in international commerce.*

Our nation is openly committed to the endeavor to secure for the peoples in the heart of Europe outlets such as will permit them to reach the high seas and take their rightful part in the commerce of the world. The right of the rest of the world to access to these peoples is only the other side of the equation. Some such provision is regarded as indispensable to lasting good will, and hence to stable peace as well as the common prosperity.

Three types of common commercial highways—world-ways.—1. The high seas are already recognized as the common highway of all peoples. Respecting them, it only remains to insure their equitable control in the common interest of all peoples. It is proposed to secure this by means of an omninational organization, an

Omninational Confederation, if you please, in which all peoples who engage in international exchange in any appreciable way shall be represented in proportion to their participation. Some details of the mode of organization will be discussed later.

2. While the high seas are thus recognized as common commercial highways, there are certain straits and lesser waterways of other types that are not now equally open to unrestricted commerce. It is proposed that all these shall be opened to general commerce and that they shall be placed in the care of this Omninational Confederation, whose duty it shall be to see that this freedom of use by all the nations is maintained. The freedom of these straits is not, however, to displace those proper restrictions relative to coastal and internal waters that, by common consent, are regarded as essential to national safety and the interests of domestic commerce.

3. A very special problem is the provision of outlets and inlets for peoples occupying lands in the heart of Europe and elsewhere completely surrounded by the lands of other peoples. Commercial highways for these peoples can therefore only be *thoroughfares on land*. In solution of this critical problem, it is proposed that there shall be provided under the authority of the proposed Confederation omninational rights of way on the land, on which shall be located railways, roadways, and other thoroughfares, so placed and so maintained as to constitute world-ways for intercourse between these peoples and the rest of the world.

Pre-eminent domain.—As a basis for establishing and administering these common highways, it is proposed that the Omninational Confederation shall assume the right of pre-eminent domain on the ground of common welfare in precisely the same way that states, provinces, municipalities, and even townships now exercise the right of eminent domain.

These world-ways as barriers against aggression.—The proposed world-owned land-lanes are to be so chosen as to constitute also *barriers against aggression*. As the property of the world at large, taken over for the common welfare under the principle of pre-eminent domain and placed in charge of the Omninational Confederation, it will be within the province of this representative body

to interpose objections to the violation of these highways by one people in attacking another people or by one group of peoples in attacking other peoples, if such attacks contravene the general welfare. It shall be within its power to enforce its protest, if necessary, by an Omninational Guard maintained for the purpose of protecting and policing the omninational property. The very policing of these highways will in itself be a means of preserving the peace.

The relations of the world-ways to national boundaries.—To serve as such barriers to aggression and at the same time to serve equally the peoples adjoining these highways on either side, they are to be placed on or near international boundaries so far as topographic and other natural conditions permit, but they are not themselves to be the boundaries, which will be fixed independently. The world-ways may therefore depart from them more or less freely as conditions require. While broadly serving the commercial interests of the world in general, they will be specially tributary to the interests of the adjoining peoples, as are all highways. The project, should, therefore, if fairly understood, be very kindly received by the peoples of the lands traversed, and the benefits arising from these highways should promote good will toward their establishment, as also toward their maintenance in times of stress.

The proposed gridiron of omninational highways.—In the area most involved in the world-war, it is proposed to establish four north-south omninational highways stretching from appropriate terminals on open-water bodies at the south to similar terminals at the north. Crossing these from east to west four highways of like type are proposed, the whole forming a gridiron of omninational thoroughfares. These are so placed and so related to one another as to give essentially all the peoples of Central Europe outlets and inlets for universal commercial intercourse, as may be seen from the accompanying map. The principle back of this gridiron of commercial highways is precisely that which underlies the public highways of enlightened lands. Put continents in the place of counties, put nations in the place of farmers and lot-holders, and the proposed world-ways serve much the same function as our streets and public roads. What our forefathers put in the place of

Indian trails, we propose in analogy to superpose on the dynasty-ridden domains of Central Europe and Asia Minor. Some of the leading details will be discussed later.

The highway problem of Asia Minor.—The Asiatic area of conflict presents some special difficulties and may therefore be treated on a special basis. The Black Sea on the north, the Bosphorus, the Sea of Marmora, the Dardanelles, and the Aegean Sea on the west, and the Mediterranean on the south, mark off Anatolia in a definite natural way as the appropriate home of the Ottoman peoples. Nowhere else are these peoples the preponderant nationality. Even here their dominance is qualified by the presence of numerous Greeks, Armenians, and the modified descendants of many ancient peoples. To complete the delimitation of Anatolia according to the method of this scheme, it merely remains to open an omninational highway from the northeastern apex of the Mediterranean over the plateau to the Black Sea, separating Armenia from Anatolia in response to the call of outraged justice. Neither sharp racial limits nor convenient topography lends itself very happily to this demarcation. No doubt lack of a marked natural boundary has contributed largely to the racial intermixture that prevails, but without question the massacres of five centuries are the chief reason why the Armenians are not more preponderant than they now are in their home region on the culminating plateau that has its apex at Mount Ararat.

There is sore need for an open highway across the heart of Anatolia, not only for the sake of its own people, but for that of the lands beyond, which have suffered grievously in the past from isolation and oppression. It is proposed therefore that the Omninational Confederation shall take over and administer the Constantinople-Bagdad railway and develop its connectons so as to make these serve as a gridiron of thoroughfares to and from the rich fluvial plains, as well as the oases of the arid tracts of the Near Orient. Under proper supervision, six productive, prosperous peoples should arise where poverty, degeneracy, and suffering have prevailed for five centuries. All these six lands—Anatolia, Armenia, Mesopotamia, Syria, Palestine, and Arabia—are sufficiently distinct in physical features, races, languages, traditions, social and religious institutions, to entitle them to be treated as independent

MAP OF PROPOSED OMNINATIONAL

PROPOSED OMNINATIONAL HIGHWAYS (IN COLOR)

MESOPOTAMIA

peoples, though they will need help, guidance, and guardianship while they are developing themselves. All have been great in the past and all may be again. It will be a blessing even to the Ottoman people to be relieved of their debasing dynasty and the burden of the name that has fastened itself upon them—"the unspeakable Turk." Relocated in their old home in Anatolia and developed anew on modern lines as Anatolians, they should in time take a worthy place in the progressive world, for the Ottoman people, fairly judged apart from their dynasty, are not without their merits and possibilities.

Relations of omninational highways to other transportation lines.—The main dependence for rendering these highways effective is placed on railways either taken over or built anew by the Confederation. It is assumed that they will have a construction, equipment, and administration worthy of the high purpose they are to serve and of the world-body that establishes and administers them. It is further proposed that, so far as may be wise and practicable, these highways shall be supplemented by waterways on rivers, lakes, and canals, and by common roadways adapted to motor travel, so that the whole shall be as effective and adaptable a combination as may be. Furthermore, it is proposed that these omninational lines shall work in as close co-operation as practicable with the national and corporate lines of the same regions, helping to bind the whole into a mutually helpful system of transportation. An important practical distinction between omninational and other lines will be discussed later.

The bearing of the proposed measures on the thirst for national possessions.—The thirst of overlords and feudal castes for greater and greater possessions is easily understood, but fair-minded people of the benevolent order see little reason to desire the irksome task, the great expense, not to say the critical risks, incurred in subjugating and governing weaker peoples, *provided* fair opportunities for economic intercourse with them can be secured *without such grave burdens*. Under the inherited habit of exploiting subject peoples, possession has naturally been regarded as a prerequisite to economic advantage, and so the cost and danger of acquiring and administering national possessions has been accepted as the price of such advantage. But if open doors and fair opportunities can be

maintained by common action, what remains to justify these costs and risks, not to add the inevitable fear of revolt, the constant preparedness to suppress it and to defend possession against rivals, together with the debasing moral atmosphere that surrounds the relation of master and subject? The proposed opening of all doors by a representative omninational body should lead to a lingering death of the inherited thirst to possess and to rule the lands of other peoples. If this be thought more ideal than real, let the spirit that has guided the people of the United States in their rise to power and prosperity, *as actually expressed again and again in action and in attitude*, bear witness.

The province assigned the Omninational Confederation.—The dream of a single world-nation with a single world-government without doubt is highly laudable and will perhaps in time be realized, but in the cold light of existing facts the full realization of this great dream hangs on the attainment of a state of human evolution only likely to be reached by the world at large in the distant future. Many peoples are yet in the infantile stages of their development and are still far from a state of fitness for full participation in world-management. Grading up from these children of our race, there are peoples in various stages of adolescence and corresponding limitations of fitness, while even those that esteem themselves more advanced have, as this war testifies, only doubtfully entered on a state of intellectual and moral maturity.

Two things therefore seem obvious: (1) that a world-organization based on the hypothesis of national equality and governmental competency would be premature, and (2) that a governmental attempt which should try to compass all the intangible ideals that enter into the social desires and the political aspirations of the many diverse peoples of the world would prove impracticable at the present time.

On the other hand, it seems equally clear that certain great steps in advance are practicable and are therefore imperative. The groundwork for such steps seems manifest on due consideration.

1. *The commerce of the world is a concrete, measurable activity.*
2. *It offers a workable basis of control and administration.*

3. Inasmuch as each nation's commerce is definite and registrable, *a graded participation in control and in administration is entirely practicable.*

4. *Such control and administration is in its nature both just and conducive to the common advantage.*

In the light of these two groups of contrasted deductions, it is now to be said, with emphasis on the distinction, that the Omninational Confederation is *not* proposed *as a mode of political or social government but as a co-operative economic agency* controlling the essence of international affairs. It involves, to be sure, such commercial regulation and such control as is necessary to realize the purpose sought, but there its governmental function ends. It is assumed that so long as races and peoples remain as diverse as they now are it is best that each distinct nationality shall give shape to its own political and social devices and shall control its own local institutions as suits itself best. The proposed omninational effort is limited to concrete affairs of wide international concern, *affairs in which co-operation is indispensable.* The proposal is in the line of divorcing what is essentially racial, political, social, and provincial from what is economic and general. Interchange of products is always necessary for mutual comfort; not seldom necessary to escape starvation, as we now realize as never before, and as we are likely to realize more fully still as the need for food nears the limit of food production.

It is believed that a movement which draws a practical distinction between *political government*, on the one hand, and *co-operative economic regulation*, on the other, will gradually remove the inherited motive for aggressive rulership. Such removal should open the way for a freer adaptation of the special forms of government to the preferences of the peoples concerned; it should tend to abate the thirst for empire.

The functions assigned the Omninational Confederation.—It is proposed that the Omninational Confederation—

(1) Shall take entire control of the policing of the high seas and of such regulation of international commerce upon them as may be necessary and equitable;

(2) Shall take control, in the same sense, of such straits, channels, and lesser waterways as are essential to free international commerce;

(3) Shall exercise the right of pre-eminent domain on the land so far as required in providing avenues of intercourse between distinct nationalities, and shall have power to establish, maintain, and operate such thoroughfares; and

(4) Shall have all the powers requisite to carry into effect the purposes herein set forth.

The ruling bodies of the Omninational Confederation.—To be effective, the Omninational Confederation must be fully organized in a way appropriate to the specific work assigned it. This is likely to be more nearly analogous to corporate business than to the multitudinous legislation of ordinary political governments, and so the function of the ruling bodies may perhaps better be shaped after the most approved patterns of great corporations than after those of political bodies, but of course different forms of organization are consistent with the general scheme, and the plan herewith outlined is merely tentative.

It is important however here to note that the basis of the scheme, international commerce, makes it possible to give each nation that enters the Confederation *a voting power in strict proportion to the part it takes in international commerce*. This gives not only an ethical basis for the conduct of the affairs of the Confederation, but great adaptability to the practical working of the plan as in the case of business corporations. Since nations are negligible that take no part in international commerce, either as carriers or shippers of commodities, all recognizable nations may participate proportionately in the Confederation, and it thus satisfies the title Omninational.

The two factors that make up international commerce, (1) transportation and (2) commodities transported (exports and imports), are sufficiently different to constitute a working basis for two types of representatives, as also two sections of the ruling bodies, and so secure the well-known advantages of a bicameral organization.

It is proposed that the several nations be represented by delegates, who shall form a Congress the function of which shall be to determine the general regulations that shall govern the conduct of

the affairs of the Confederation and to choose directors and certain other officers who shall be more immediately charged with the business of the Confederation. The directors are to be chosen on the proportionate basis and their voting powers in the decisions of the directorate are to rest on this basis. Further suggestions respecting the ruling bodies and the judiciary will be made after the remaining features of the scheme are sketched.

The permanent seat of the Confederation.—It is proposed that the permanent seat of the Omninational Confederation shall be Constantinople, for these reasons:

1. Constantinople has long formed the center of those chronic difficulties that have called for some such remedy as is herein proposed. For nearly five centuries almost continuous trouble has centered about or radiated from Constantinople. The body that is to bring peace out of this prolonged agony may well sit at the seat of trouble.

2. The permanent occupation of Constantinople by a body representing the commercial interests of the whole world would of itself settle one of the most serious problems of the Near East, the possession of this strategic situation; possession by all nations jointly, not by any one alone.

3. The nationalities that most need to be led into the newer and broader national spirit would be nearest the new seat of influence.

4. Placed near the meeting-point of the three grand divisions of the Eastern Hemisphere, the Confederation would be seated where its later work, the economic development of these grand divisions, especially Asia and Africa, would be close at hand.

The naval and military forces of the Confederation.—Two vital considerations are to be met in providing the Confederation with an efficient navy to protect and police the seas and enforce its decrees, if that shall be necessary: (1) There should be no increase in naval or military armament; (2) there should be no weakening of the control of the right-minded nations so long as danger from the inherited spirit of aggression lasts. At the same time, it is agreed by the right-minded nations that a reduction of armament is extremely desirable if not imperative, because of the great financial burdens already incurred in the war. How can these requirements be met?

1. It is proposed that the Confederation shall take over war-vessels from the present navy of each of the nations, by definite units, such as a war-vessel with its officers, crew, marines, and full equipment, in such number as shall represent its equitable proportion of the navy of the Confederation. Let this proportion on the average be *one-third* of the existing navy, leaving on the average two-thirds remaining in the hands of each nation. Let one-half of this two-thirds be retained as the domestic navy of each nation, and let the other half be retired by such nation and be dismantled by it, so far at least that it shall not be an immediate menace to any other nation but still could be restored to service, if emergency required, in less time than any other nation could build vessels anew. Let all building of new battleships, and other vessels for which there is no need except in case of war, be discontinued by all nations.

Now under this plan (1) the *ratio* of naval power between the several nations remains practically the same as it is now; (2) the relative preparedness for war is the same; (3) the chief need of war-vessels is removed by the fact that the policing of the seas is taken over by the Confederation; (4) its system of parity removes the costly race to keep each national navy ahead of rival navies; (5) one-third of the existing expense of maintenance is saved to each nation; and (6) the burden of maintaining the Confederation's navy could probably be met by levies on the commerce protected by it, but if not it would be distributed on an equitable basis. The saving would thus be large, there would be little change in the relative power or preparedness of the nations, and any minor change that might be involved would be merely such as is likely to arise inevitably from the growth of commercial activity. It would be the height of prudence for all nations liable to suffer a change of relative naval power from relative declines in international commerce to forestall the adverse conditions of the future by entering into an equated world-scheme before their advantages pass away. It is important to note that by this plan of division of existing navies the nations that now have strong navies and are active in international commerce take no serious risks in trying the omni-national scheme; for, let it be emphasized, the Omninational Navy

is to be made up of national units in equitable proportion, so that should the Confederation go to pieces the pieces would naturally fall back into the several national navies and their relative strength would be much the same as before and as they now are. The scheme does not destroy or trammel national preponderance but merely adjusts it to the rest of the world and the rest of world to it on a basis of ethical parity.

All existing submarines should be scrapped and heavy penalties visited upon every surreptitious effort to make any new ones. Submarines promise little or no constructive service to mankind; they are inherently dangerous to the common welfare. There can be no use or excuse for them, except on the presumption of war; and it is that presumption that we are trying to remove.

Land forces adequate to protect and police the borders of the straits, the terminal ports, and the omninational highways are to be taken over, in military units, from the several nations on the proportionate basis. The effect of this on the existing balance of power will be of much the same order as that of the sea forces, but the details are less readily stated and perhaps less important.

The manufacture of arms and munitions.—As a supplementary precaution against war and especially as a source of safety in peace, it is proposed that the several nations for themselves respectively, and the Omninational Confederation for itself, shall take over *a complete monopoly of the manufacture of arms and explosives of all kinds*, and that no person shall be allowed to make, possess, carry, or use arms or explosives of any kind except under regulations and provisions instituted and maintained by the several nations respectively for their own territories and by the Confederation on the seas and world-ways, the purpose being to suppress the harmful use of arms and explosives now so widely and destructively prevalent. Ample provision would of course be made for the sale of explosives by the respective governments for use in mining and for all other legitimate purposes, as also for the use of arms for the destruction of obnoxious, harmful, and dangerous animals and in legitimate sports.

This universal monopoly of munitions would greatly aid in the suppression of brigandage in ill-governed lands and of riots everywhere, as well as assist in the ordinary policing of all countries. A

rigorous system of accounting and inspection of the national factories of munitions would aid in maintaining an equitable apportionment of these to industrial needs and to the domestic armies and navies agreed upon between the Omninational Confederation and the several nations.

The financing of the Confederation.—The moral basis for financing the Confederation lies in the great saving of expense and man-service that will be secured by the common policing of the highways of international commerce on sea and on land. It is obvious that when such a system is once organized and has secured the confidence of all right-minded nations, the proportionate expense of insuring peace throughout the world will be reduced to a mere fraction of what is now expended in the maintenance of the several great armies and navies of the world. Since each nation will thus be relieved of an enormous burden of expense and loss of service, it will be but a matter of just reciprocity and of honor to meet its part of the expense of the common body that has brought the relief.

But after the system is once established, even this contribution may not be necessary. It is proposed that the revenues from the commerce benefited shall pay the cost of the benefits it receives, as nearly as may be, by appropriate charges for shipping facilities, traffic rates on the railways, and various fees fixed with a view to meeting the costs, upkeep, and administration involved.

The credit of the Confederation, resting upon the credit of the constituent nations, should be an ample basis for such loans as may be required to inaugurate new enterprises. At the outset, however, the specific financial aid of the constituent nations may be required.

DETAILS AND SUPPLEMENTARY DISCUSSION

The foregoing sections have been abbreviated as much as seemed consistent with clearness, to bring the scheme rapidly under view. Some important details need further statement, but even these must be too much abbreviated to be quite adequate.

Difference between world-ways and national thoroughfares.—An important distinction between the omninational thoroughfares on the one hand and all private, national, or even international thoroughfares on the other, whether railways or otherwise, lies in

the fact that the former are *a part of the world domain*, are in effect an extension of the high seas, while the latter are integral parts of the several national domains. This is a vital matter when the collecting of customs is considered. The bordering lines of the world-ways on land would be precisely like the borders of the sea, so far as customs regulations are concerned. Under the omninational scheme the several nations retain the same rights and privileges respecting tariffs and like fiscal systems that they now enjoy, and so the border lines of the land lanes alongside nations that impose tariffs would need to be supplied with custom-houses such as are maintained on sea borders. The normal effect would be to limit the number of stations on the omninational railways to those whose international traffic would support custom-houses. This would tend to throw the subdistribution of imported goods on the infranational lines. It is a fair presumption, however, that the increase of imports due to the facilities offered by the world-ways would more than compensate for the expense of maintenance of frequent custom-houses and that the system would be a source of tariff revenue, where tariffs are maintained, in addition to its other benefits. The bonding system would of course be applicable here as in the present system.

The terminal ports of the world-way system.—The terminal ports would obviously tend to become cosmopolitan; due recognition of this in practical provisions would be required. These provisions might go so far as to make these terminal ports free cities, with governments and fiscal systems of their own under the protection of the Confederation, or they might take the form of concessions similar to those in vogue in China, but probably in most cases less specific regulations would amply accommodate the requirements of the various peoples that assembled at the terminal ports in the natural course of business. The whole tendency of the scheme would be toward general cosmopolitanism, involving the removal of those provincialisms that make it difficult for diverse peoples to live peacefully together. Ultimately the need of any special provision for any particular people would disappear.

Some of the leading features of the omninational thoroughfares proposed in the disturbed area.—The general principle of world-ways

on land applies to the whole world, but only the war-disturbed area is specifically considered here and that only briefly.

1. The most central world-way of the proposed north-south group of Middle Europe is made to start from terminals at Saloniki on the Aegean Sea and to end in terminals near Memel at the mouth of the Niemen on the Baltic Sea, as shown on the accompanying map. It follows the valleys of the Vardar and the Morava, the eastern border of the Theiss plains, crosses the Carpathians through the Ungvar Pass, and follows the eastern border of the land inhabited dominantly by the Poles to its northeastern angle, beyond which it lies on the border between the Lithuanians and East Prussians and has its terminals near Memel at the mouth of the Niemen. It is a nearly north-south line, well suited to furnish an avenue of egress and ingress for the peoples of Serbia, Bulgaria, Rumania, Hungary, Czecho-Slovakia, Ruthenia, Poland, White Russia, East Germany, and Lithuania. Just how, as a world-owned tract under control of a world-force and protected against threatening fortifications, this world-way should serve as a barrier between peoples recently in conflict may best be seen by consulting the map.

2. The easternmost of the proposed north-south world-highways starts from terminals on the Bosphorus, runs through terminals on the Black Sea—whose western shore it skirts—and, following the valley of the Dniester, joins the preceding thoroughfare near the junction of what is now Galicia, Poland, and Russia. Thence northward it unites with the preceding to form a common trunk line to the Baltic. It is designed to give an avenue of egress and ingress for the peoples of Thrace, Bulgaria, Rumania, Ukrania, Ruthenia, Poland, White Russia, East Prussia, and Lithuania. Just how it should serve as a barrier between peoples recently at strife may be seen by consulting the map.

3. The west-central line of the north-south group starts from Fiume and Trieste at the head of the Adriatic and runs northeasterly to the junction of Croatia-Slavonia, Austria, and Hungary; thence turning northerly it runs near the border between Hungary and Austria to Presburg, at the mouth of the March valley, which it follows northward across the land of the Czecho-Slovaks to Oppeln on the Oder, from which point it is made to run within the border

of the area where Polish speech prevails, to sea-terminals on the Gulf of Dantzig. This is intended to serve as bond and barrier for the Italian, Jugo-Slav, Hungarian, Austrian, Czecho-Slovak, Polish, and German peoples, giving at once outlet and inlet to and from the Adriatic on the south and the Baltic on the north. Its relations to the problem of future peace are quite as critical as either of the preceding.

4. The westernmost of the north-south highways follows the great natural trench of the Rhine. At the same time it is intimately connected with the main east-west thoroughfare in the valley of the Danube, and the two are best considered together, for they should really form a single thoroughfare. Starting from terminals on the Black Sea near the mouth of the Danube—the same terminals that serve the easternmost north-south highway—this thoroughfare follows approximately the course of the Danube to its confluence with the Drave, which is then followed to its headwaters in the Alps near Brenner Pass in the Tyrol. Awaiting the construction of a more direct connection with the Upper Rhine by tunnel, it is proposed to use for the present the route over Brenner Pass and up the valley of the Inn to the Rhine. Thence the highway follows the Rhine to sea-terminals on the waters of the North Atlantic at the Sheldt and at the Dallart and perhaps at other points. A branch may be made to diverge from this near the angle in the Upper Rhine and extend thorugh Switzerland and France to terminals at Marseilles but this is outside the area directly involved in the war-settlement. The great east-west thoroughfare through the valleys of the Danube and the Rhine should provide at once a bond and a barrier between the peoples of Southern Russia, Rumania, Bulgaria, Serbia, Hungary, Croatia, Slavonia, Italy, Austria, Switzerland, Germany, France, Belgium, and Holland. This crosses the two central north-south highways as shown on the map and gives them east-west connections.

5. A more southerly east-west highway is proposed to pierce the heart of the Albanian-Macedonian wilds and introduce a peacemaker between the peoples of Albania, Montenegro, Serbia, and Greece, and at the same time unite the Saloniki and Bosphorus terminals. Starting from the mouth of the Drin on the Adriatic,

it follows the course of the Drin eastward and then southward past Lake Ochida to the junction of Albania, Serbia, and Greece, thence easterly near the borders of Serbia and Greece to Saloniki, and thence onward near the Aegean coast to the Bosphorus, where it connects with the easternmost of the north-south thoroughfares.

6. A short east-west connecting highway may be located on the border between Slovakia, Hungary, Ruthenia, and Rumania. Starting from the main central north-south thoroughfare at Presburg on the Danube, it may be made to run thence easterly near the southern border of Slovakia to the Saloniki-Memel thoroughfare, and thence onward across the Carpathians as near as may be along the border of the lands peopled dominantly by Ruthenians on the one side and Rumanians on the other, to a junction with the Dniester thoroughfare. Should Southern Germany form a separate nation, this line might be extended from Presburg northwesterly within the border of Bohemia and thence westerly to the Rhine. Should Russia spontaneously divide into independent or semi-independent states, this and the more northerly east-west line might be extended eastward on the same basis as the rest of the scheme.

7. Still another connecting east-west line may be located on the border between East Prussia and Poland, and thus connect the two main north-south highways near their Baltic terminals.

It will be seen that this scheme provides every nationality of moment in Central Europe with alternative ways of egress and ingress. The boundaries thus designated fairly represent the limits of the lands defined by dominance of race or language or both, and these are among the recognized criteria for homogeneous national organization and administration. This delimitation also fairly corresponds to the historical longings of the peoples themselves. But the details here presented are of course merely tentative and quite likely to need modification.

Added suggestions respecting the ruling bodies of the Confederation.—As remarked in the previous section relating to the ruling bodies of the Confederation, several alternative modes of forming such bodies are as consistent with the general scheme as that here offered. The one favored is sketched because it is somewhat out of the usual

line of governmental organization, in that it conforms to the methods of approved business practice, as seems appropriate in bodies that are to have charge of the world's greatest economic interests. The delegates of the nations are made to function as the attorneys of the national shareholders, while the directorate they select is made to serve as the directive and executive body. It is presumed that the nations will be wise enough in their own interests to appoint as their representatives men of affairs of demonstrated capacity and experience. The conduct of the affairs of the Confederation should follow as little as may be the precedents of political bodies and as much as possible the precedents of business bodies of the highest order. The work to be done lends itself happily to this.

It will be recalled that the proposed basis of representation and voting in all essential matters is to be proportionate to the participation of the respective nations in international commerce in the two respects, (1) shipping, and (2) shipped commodities, and that every nation that takes any measurable part in international exchange, and duly registers and reports it, is entitled to representation in the ratio of such exchange to the total exchange of all nations, be the amount much or little, the scheme thereby resting on the solid ground of strict equity and being really omninational.

For practical reasons, however, the *personal* representation should be limited to workable numbers, and so a unit of personal representation will need to be fixed. The standard unit in transportation might naturally be a given number of ton-miles, while that in exports and imports might be a given aggregate value. A basis for correlating the two would need also to be fixed. The representatives chosen on the basis of transportation might form a Chamber of Commerce, if the term suits; those chosen on the basis of exports and imports, a Chamber of Commercial Industries. In all cases where the commerce of a particular nation falls below the adopted units one delegate should be allowed, that all such nations may be represented. It is to be noted that this merely provides a personal representation; the *voting power* would be based solely on the commercial record of the nations, and in these cases would of course be small.

It will be necessary to define with care what constitutes *international* commerce in distinction from domestic commerce. The essential point will be to keep from the record on which representation and voting is based all commerce that is specially stimulated by financial considerations which favor one nation over others, as by a differential tariff or its equivalent. *A tariff that affects all the nations of the Confederation alike is entirely consistent with the equities of the scheme*, so far as the scheme is concerned—it is not a free-tariff scheme—but a *differential* tariff that tends to direct commerce toward one nation rather than another disturbs the parity of the system. All shipping as well as all commodities so affected should be classed as domestic or preferential exchange and excluded from the record on which representation and voting power are based.

The average of a period of years is likely to be a fairer basis for determining representation and voting power than the last annual record; perhaps the average of a five-year period might be best, the group of years to be changed annually by dropping out the first of the five years when a new year is added.

Subject to the qualifications specified, it should be the privilege of each nation to elect or to appoint its delegates to the Congress in any way it may choose, and where entitled to several delegates to determine whether they shall vote as a unit or otherwise.

It is proposed that the delegates so chosen from the several nations shall constitute the Congress of Delegates, and that this shall organize into two chambers on the basis of the particular phase of international commerce they represent.

The Congress of Delegates should have power—

(1) To enact general laws for the regulation and conduct of the affairs of the Confederation.

(2) To fix the terms of office of the directors chosen by the national delegates. These terms should be sufficiently long to secure the results of experience.

(3) To choose certain general officers to be determined in the matured scheme as adopted.

The directorate might well also consist of two bodies, one appointed by the Chamber of Commerce, whose functions should relate to the shipping interests, the other appointed by the Chamber

of Commercial Industries, whose functions should relate to imports and exports. The directors of both classes should represent the interests of the respective nations by whose delegates they were chosen, and should have the voting power of those nations. The conferring of voting power by proxy should be recognized.

The functions of the directorate would be to carry into effect all the purposes of the Confederation in essentially the same way that the directors of a corporation carry out its purposes. The specific powers conferred on the directorate should have similar range and fulness.

For the judiciary of the Confederation it is suggested that there be four courts, (1) a Court of Inquiry, whose functions shall be the determination of the facts in the cases submitted in as scientific a spirit and in as thoroughgoing a way as possible, and to report its findings to the second court, (2) a Court of Decision, whose function shall be to decide on the equities and the legal aspects of the cases brought before it, on the basis of the facts submitted by the Court of Inquiry, but it should have the power to remand any case for further investigation or to institute investigation on its own behalf; (3) a Court of Appeals, with the function implied by its name; and (4) a Court of Arbitration or Conciliation, to aid in settling controversies without formal trial. This last would often consist of special courts formed by the agreement of the parties in controversy for the arbitration of given cases.

The judges in these courts should, if a practicable scheme can be found, be appointed by the Supreme Courts of the constituent nations, co-operating on the proportionate basis that runs through the whole scheme. No two judges in any of these courts should be appointed from the same nation.

A GEOLOGICAL RECONNAISSANCE IN HAITI

A CONTRIBUTION TO ANTILLEAN GEOLOGY

WILLIAM F. JONES
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INTRODUCTION

The following paper is the result of observations made during several months' work in Haiti during the spring and summer of 1918 while engaged on private work. The localities visited for

economic purposes were so widely scattered that the writer was forced to cover a large part of Haiti. Observations made are, therefore, somewhat scattered but a fairly accurate geologic section from the south coast to the north range of mountains is the result. Many of the problems could be only noted and left for future work which the writer expects to undertake.

Haiti has received but scant attention from geologists. Tertiary fossils have been collected by several people, not geologists, and have been described in the literature from time to time. L G. Tippenhauer, a civil engineer of Port-au-Prince, has published a series of maps and papers on Haiti.[1] His efforts deserve great commendation, though his stratigraphy leaves much to be desired. His text is largely geographical. His geologic mapping in so far as contacts go is generally accurate but similar formations are not always so recognized. His topography is excellent and his delineation of trails and roads uncanny in its accuracy.

With such maps available, and with a large part of Haiti, north of Port-au-Prince, of open and bare country and with excellent continuous rock exposures, the region probably is more ideal for field observation than any of the other islands. The several formations are here developed in what is doubtless their greatest thickness, and a cross-section of Haiti is a fairly complete study in Antillean geology.

In the neighboring republic of Santo Domingo practically no work has been done since the early work of Gabb,[2] excepting the recent work of Maury on the Tertiary faunas of the Rio Yaqui del Norte.[3]

The writer wishes to acknowledge the free use of the Tippenhauer maps and to use this means of expressing his gratitude to the enlisted men and officers of the U.S. Marine Corps who are stationed as officers of the Gendarmerie d'Haiti in the larger villages of the

[1] "Beiträge zur Geologie Haitis," *Peterm. Mitt.*, Bd. 45, pp. 25–29, 153–55, 201–4, 1899; Bd. 47, pp. 121–27, 169–78, 193–99, 1901; Bd. 55, pp. 49–57, 1909.

[2] W. M. Gabb, "On the Topography and Geology of Santo Domingo," *Trans. Am. Phil. Soc.*, XV (1873), 49–260.

[3] C. J. Maury, "Santo Domingo Type Sections and Fossils," *Bulletins Am. Pal.*, Nos. 29, 30, 1917; and "Santo Domingan Paleontological Explorations," *Jour. Geol.*, XXVI (1918), 224–29.

country. Their hospitality and assistance makes traveling in that country a real pleasure, where otherwise it might be anything but such.

TOPOGRAPHY

The Gran Cordillera of the island, which attains its greatest development in Santo Domingo, forms in Haiti the north range, one of three well-defined, generally parallel, ranges in the latter country. The north range forms the north peninsula of Haiti and if continued west and east from Santo Domingo, forms the Cordillera of Cuba and Porto Rico, respectively. In Haiti the highest elevation attained by this range is about 1,500 meters, while in Santo Domingo it attains in Loma Tina an elevation of over 3,100 meters, the highest peak of the Antilles.

The central range, called the "Chaîne des Mateux," extends from the west coast on the south of St. Marc to the Caribbean Sea in Santo Domingo, and attains an elevation of about 1,700 meters. These two ranges, which trend generally S. 60°–70° E. are connected by the range of the Montagnes Noires, which trends S. 45° E. and attains an elevation of 1,500 meters. Between this latter and the north range is the central plain of Haiti, which drains, not to the east, but by a deep cut through the Montagnes Noires to the west.

The south range, forming the south peninsula, attains, in the Montagne de la Selle, an elevation of about 2,700 meters, the highest point in Haiti. This range trends nearly east and west.

Between the south and central ranges and extending from the Bay of Port-au-Prince to the Bay of Barahona in Santo Domingo is a depression about fifteen to twenty kilometers wide, bounded along its entire length by the precipitous faces of the ranges on either side. Much of this depression is below sea-level and contains two lakes, both below sea-level but at different elevations. The writer expects to present a paper at some future time on this rather unique locality.

With the exception of the south range the mountains of Haiti are generally bare in appearance and a large portion of the northwestern part of the country is even quite arid. Valleys are generally fertile. The central plain is generally open grass-covered

country and in its southern part, where erosion has dissected it, presents in places the appearance of "bad" lands.

STRATIGRAPHY

A. PRE-TERTIARY ROCKS

Old Complex.—The Gran Cordillera of Santo Domingo consist essentially of a series of metamorphosed shales, sandstones, and conglomerates with extensive areas, or belts, of syenite. Gabb[1] called the metamorphosed series the Sierra group. Most of these sedimentary rocks are highly schistose. The structure, where decipherable, is complicated, forming even fan folds. Structural axes are parallel with the axis of the range.

These rocks are exposed over much of the north range of Haiti and generally lie on either side of a central intrusive belt. Tippenhauer's mapping of these areas is generally correct. Smaller areas of these rocks occur in valleys cut in the range of the Montagnes Noires. The age of these rocks is unknown. Gabb[2] called them Cretaceous, and Tippenhauer, Eocene. Both are probably wrong. The limestones from which Gabb collected *Ammonites* in Santo Domingo are undoubtedly unconformable with the schistose series. P. Frasor as early as 1888 argued an Archean age for these rocks.[3] The same series appear in Cuba and there form the base for all subsequent formations. In Porto Rico, Berkey's "Older Series,"[4] which he calls Cretaceous, are without doubt the same as the Haiti–Santo Domingo rocks though less metamorphosed. Some of the limestones and tuffs described by Berkey, especially his Coamo limestone, may be Cretaceous and correspond to Gabb's Cretaceous. Berkey's cross-section shows this Coamo member in such position that there may well be an unconformity at its base. Gabb apparently found a limestone member in the schist series and near by he found a limestone containing *Ammonites* and still in the same vicinity he found great thicknesses of limestone which are without

[1] *Op. cit.*, p. 83. [2] *Op. cit.*, p. 87.

[3] *American Geologist*, XXI (1898), 250 (citing earlier statement).

[4] C. P. Berkey, "Geological Reconnaissance of Porto Rico," *New York Acad. Sci., Annals*, XXVI (1915), 1–70.

doubt Tertiary and which flank the entire south face of the north range, and in attempting to correlate these three he found it puzzling.

Cretaceous.—Tippenhauer[1] described a formation in Haiti of undoubted Cretaceous age, similar to part of the Cretaceous series of Jamaica. This locality has not been visited by the writer. It is thought highly probable that Cretaceous rocks exist in the south peninsula. Isolated areas of sandstones, shales, and limestones occur in this region, expecially between Leogane and Jacmel, where the remnants are engulfed in late Tertiary intrusives and are generally metamorphosed (see Plate V, Section B). In this same section on the north flank of the hills is exposed a considerable thickness of tuffs which correspond in character with the Cretaceous series of Jamaica.

In the Monti Cristi Range of Santo Domingo Gabb[2] found *Orbitoides*. There is probably present there an upper Cretaceous formation of sandstones and shales, possibly the equivalent of the Richmond of Jamaica, which he failed to differentiate structurally from the overlying Miocene.

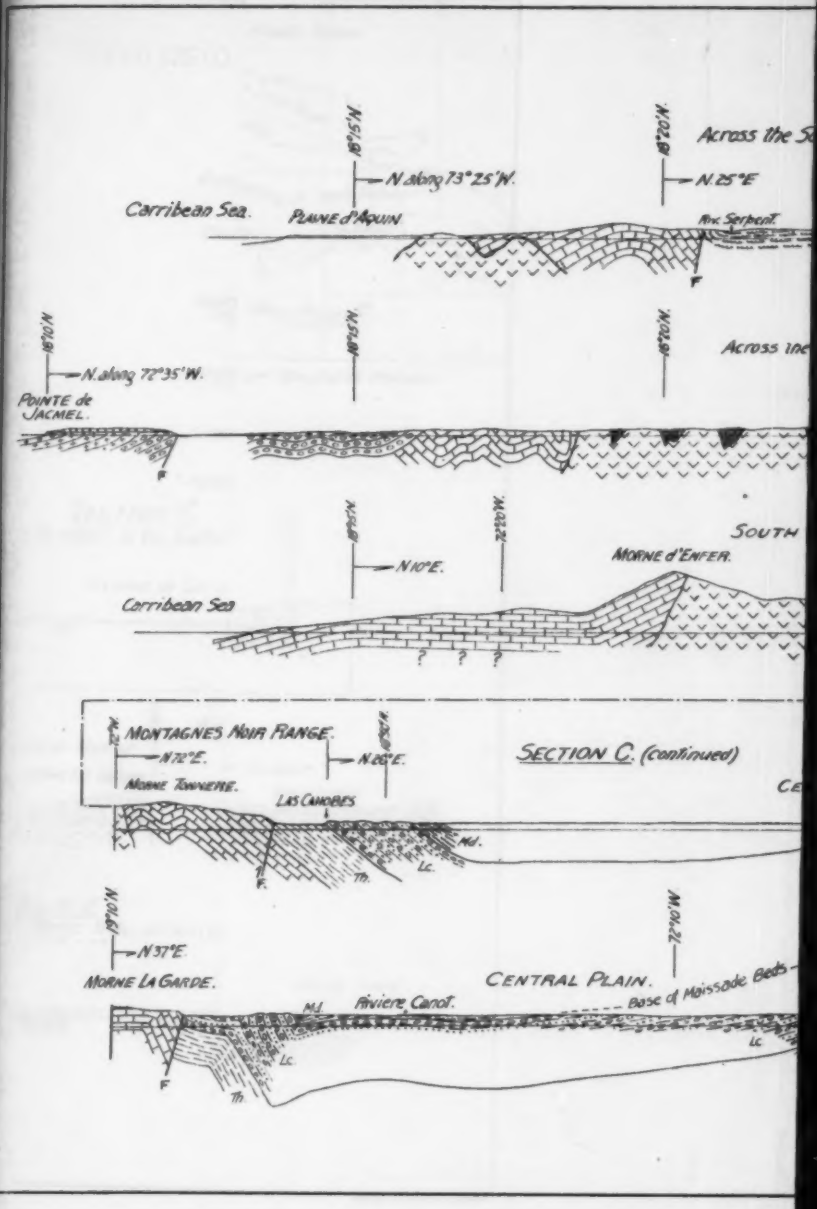
B. EARLY TERTIARY LIMESTONES

The several thick formations of limestone in Haiti have not been differentiated and there are several problems connected with them which are worthy of future work. With the exception of small areas of volcanic or intrusive rocks the entire central range, the Montagnes Noires, and a large belt along the south side of the north range are of limestone. Great thicknesses are developed and owing to continuous exposures the entire series can be carefully studied. From casual observation the series seems to consist of a basal member with considerable sandstone and above this a great thickness of very compact, light-gray or white, foraminiferal limestones, often very finely bedded but generally massive, and with intercalated beds of coralline limestone (Figs. 1 and 2).

This series rests on the older complex and the unconformity is well exposed at several places along the south side of the north

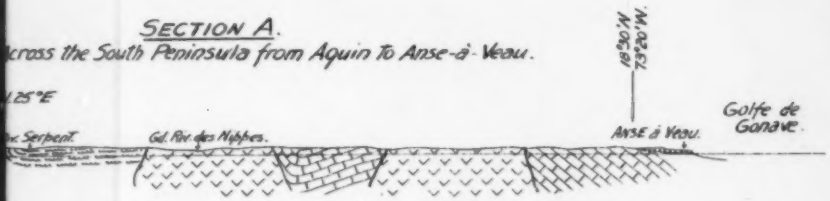
[1] L. G. Tippenhauer, *Die Insel Haiti*, Leipzig, 1893, p. 85.

[2] *Op. cit.*


N.15°W.
N. along 73°25'W.
Caribbean Sea.
PLAINE d'AQUIN
N.20°W.
N.25°E
Across the S
Arc. Serpent.
F
N.10°W.
N. along 72°35'W.
POINTE de JACMEL.
N.15°W.
N.20°W.
Across the
F
N.15°W.
N.10°E.
N.22°W.
SOUTH
MORNE d'ENFER.
Caribbean Sea
? ? ?
MONTAGNES NOIR RANGE.
N.72°E.
N.25°E.
SECTION C. (continued)
MORNE TONNERRE.
LAS CAHOBES
Md.
Lc.
Th.
N.10°W.
N.37°E.
MORNE LA GARDE.
CENTRAL PLAIN.
N.20°W.
Base of Maissade Beds
Md
Riviere Canot.
Lc
Lc.
F
Th.

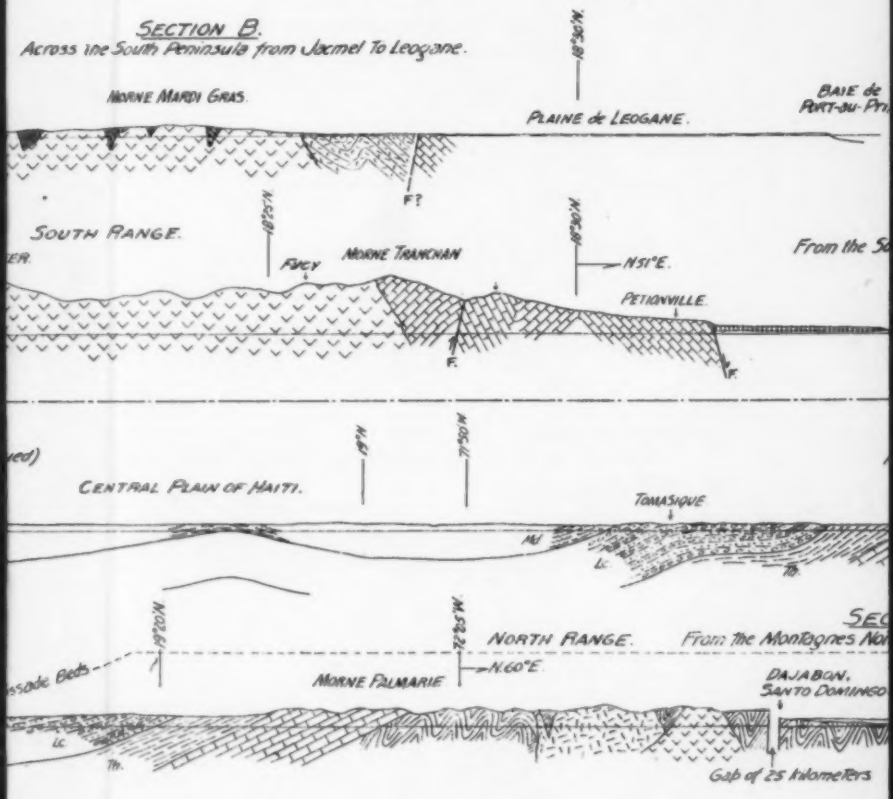
SECTION A.

Across the South Peninsula from Aquin To Anse-à-Veau.



SECTION B.

Across the South Peninsula from Jacmel To Leogane.



GEOLOGIC STRUCTURE SECTIONS AC

0 1 2 3 4 5 6 7 8 9 10 Kilometers.

1 / 200,000.

de
ave.

Pleistocene. — Elevated coral reefs.

Unconformity

Pliocene ? — Conglomerates and limestones.

Unconformity

Miocene-Oligocene. — MANSSADE BEDS, shales and marls.

LAS CAHOBES BEDS, sandstones and co

THOMONDE BEDS, shales.

Oligocene-Eocene. — Limestones.

Unconformity

Cretaceous ?

Unconformity

Paleozoic ? — Metamorphosed and schistose rock

BAIE de PORT-au-PRINCE.

SECTION C.

From the South coast to the foothills of the North Range.

N. 12° W. 22 Miles

CENTRA

N.

PLAINE de CUL de SAC.

F.

NORTH RANGE

MORNE LES GUAVES.

MONTAGNES NOIR RANGE.

N. 36° E.

MORNE d'HAITI.

N. 12° W. 12 Miles

SEC

2. From Morne

THOMONDE VAL

Lc.

To.

F.

SECTION E.

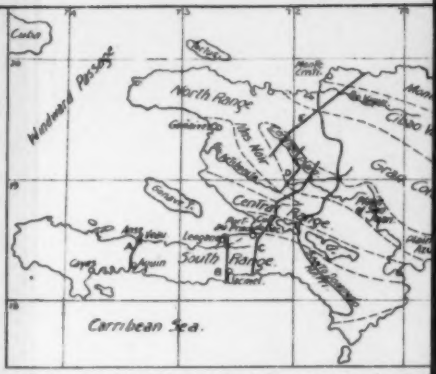
Montagnes Noir Range To the North Coast.

Top of Orthoulan Zone

DAJABON, SANTO DOMINGO

of 25 Kilometers

ACROSS HAITI.



Sketch Map of the Island of Santo Domingo showing the
and the location of the structure sections.

and conglomerates.

Tertiary intrusive rocks.

Pre-Tertiary intrusive rocks.

rocks.

NTRAL RANGE.

N12°W

N12°E

TERRE ROUGE.

PLAINE de TRAINON

Lc.

Th.

SECTION D.

Morne d'Haiti across Thanoulic Valley.

N26°W

N26°E

b. From Hinche To Cerca Cabajal.

NORT

DE VALLEY.

CENTRAL PLAIN.

Pt. Guayamuco

Hinche

MORNE PEDRIGAL.

Th.

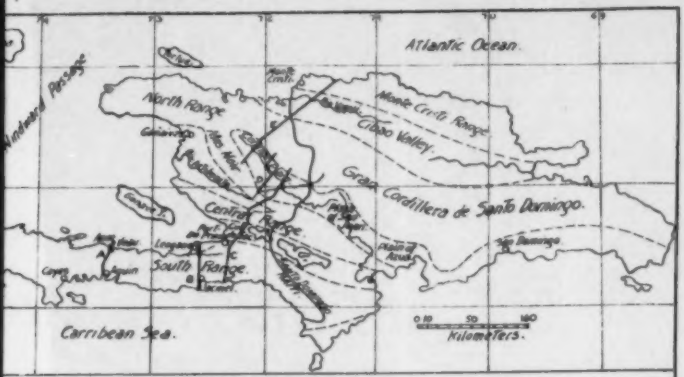
Lc.

Lc.

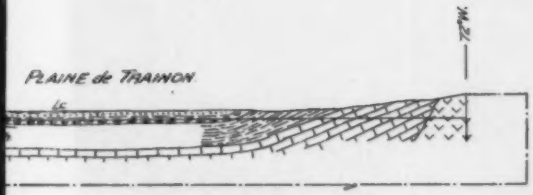
Th.

MONTE CRISTI RANGE

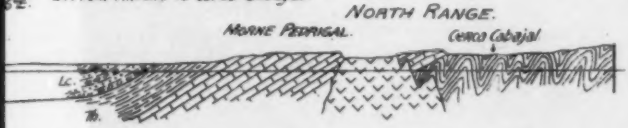
Rio Yaqui del Norte.

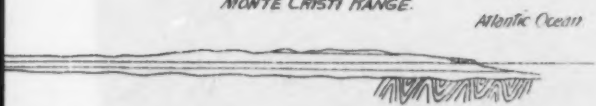


Sketch Map of the Island of Santo Domingo showing the major Topographic divisions and the location of the structure sections.



b. From Hinche To Cerca Cabajal.





range, especially near Cerca Carbajal. All along this range the prevailing dip is to the south.

Tippenhauer[1] in a section north of Gonaïves determined a thickness of 16,500 feet for this limestone series. There is probably duplication at this place. A section the writer measured between Hinche and Cerca Carbajal showed a thickness of 13,000 feet but later the conclusion was reached that there was good evidence here of duplication. There is, however, at least in this section, a

FIG. 1.—Fine-bedded, compact, foraminiferal limestone in quarry near Gonnaïves

thickness of about 6,000 feet exposed. Southeast of Port-au-Prince, on the road to Fucy there is, however, an unduplicated section of limestone whose thickness is at least 8,000 feet (see Plate V, Section C, south range).

This same limestone on the south side of the Gran Cordillera in Santo Domingo was called Cretaceous by Gabb,[2] being included by him with other limestone of undoubted Cretaceous age. Tippenhauer has called it Miocene and Pliocene and his mapping has been done largely on the basis of the color of the rock. The conclusion that it is Eocene and lower Oligocene, prior to any paleontological work, is based on its striking similarity to the Jamaica and Cuban occurrences and also because of its position relative to overlying

[1] *Peterm. Mitt.*, Bd. 45 (1899), pp. 153–55. [2] *Op. cit.*

sediments of known age in Haiti. The Oceanic series of Hill,[1] about 2,000 feet thick, corresponds in character to the Haitian series. Cuban occurrences are also similar.

Maury[2] has described the upper Oligocene-Miocene series in the Yaqui Valley of Santo Domingo and these same formations reach a great development in Haiti, where they overlie the limestone. In a section by Tippenhauer[3] he found none of this limestone on

FIG. 2.—Foraminiferal limestone on Grand Rivière de Jacmel, south peninsula

the north side of the north range and likewise in Santo Domingo neither Gabb nor Maury mention this limestone north of the range. It is apparently entirely lacking on that side of the island. Hill[4] places a gap in middle Oligocene time between his Oceanic series and the Bowden of Jamaica, the latter of which corresponds to at least part of the Miocene of Maury's section in Santo Domingo There is, however, no structural evidence of unconformity above the limestone in Haiti. Dips are generally concordant and where they are not there is evidence of faulting.

C. TERTIARY CLASTIC SEDIMENTS

General.—Overlying the Eocene-Early Oligocene limestones is a thick series of shales, marls, conglomerates, and sandstones. This

[1] *Bull. Mus. Comp. Zoöl.*, Harvard Coll., XXXIV, 1899.

[2] *Op. cit.* [3] *Op. cit.* [4] *Op. cit.*

series underlies the entire central plain of Haiti and another area south of Mirebalais and probably underlies much of the lower valley of the Artibonite River. The beds are well exposed and are folded, highly in places, especially along the west side of the central plain, so that good sections can be seen. The whole series is very thick, perhaps as much as 10,000 feet, and is, in places, extremely fossiliferous. Some small amount of detailed work was done on these rocks and some fossils collected, though the work as yet is

FIG. 3.—Las Cahobes beds near Las Cahobes

by no means systematic. The writer expects to present further notes on this series in the near future.

Referring to the central plain area, these beds occupy a broad syncline. All along the foothills of the north range, on the east side of the plain, the beds dip southwest at varying degrees up to 35°, and as far as noted the dips are concordant with the dip of the underlying limestone. On the west side of the plain the structure is complicated by sharp flexures and in many places the contact with the underlying limestone is one of faulting.

South of Hinche in the vicinity of Thomonde an asymmetric anticline strikes off the Montagnes Noires Range in a southeasterly direction and from this vicinity on to the southeast the structure underlying the plain is that of two broad synclines with the

Thomonde anticline, which becomes broad and symmetrical, in the middle and forms the dominant feature of the structure. Along the north flank of the central range the contact between this series and the underlying limestone is probably a fault.

The northern part of this plain is very flat and grass-covered. Going south there is a progressive increase in the erosional dissections and excellent sections are exposed in the several large streams north and west of Maissade. East of Hinche along the River Samana, on the road from Hinche to Las Cahobes, and in the southerly portion of the plain in general well-exposed sections are numerous.

FIG. 4.—Las Cahobes beds rising above level of the plain, east of Las Cahobes

Limestone fragments have not been noted as entering into the make-up of the beds. The material is derived almost entirely from the old Paleozoic series and the igneous rocks associated with it.

Divisions.—In Haiti for the purpose of facilitating structural delineation the writer divided this series of sediments into three divisions, purely on a lithologic basis. The distinction holds wherever the series is exposed.

1. *Lower—Thomonde Beds*

The lowest division, called the Thomonde beds, consists almost entirely of fine-grained sediments, chiefly fine, bluish, soft shales. The thickness of this member varies and it seems to be thinner along the eastern side of the central plain. Its maximum thickness

may be 1,500 feet. It is fossiliferous to some extent but no collections were made from it.

2. *Middle—Las Cahobes Beds*

The middle division, called the Las Cahobes beds, is quite different. It consists of coarser and more consolidated rocks. In

FIG. 5.—Maissade beds on Rio Blanco near Maissade. Protruding bed is composed of *Scapharcas*.

general this member may be described as an alternating series of conglomerates, which are quite hard, with pebbles usually smaller than a robin's egg; sandy shales; some beds of coarse, unconsolidated sands; thin beds of very hard sandstone which characteristically weather out to flat rounded knobs; some limy beds, and at

some places coral limestones (Figs. 3 and 4). Also characteristic of this division are several beds composed mostly of a very thick large species of *Ostrea*. In other beds are myriads of *Scapharcas*. This division is quite fossiliferous, the conglomerate members and many of the sandstone beds, however, being generally devoid of fossils. No complete collections were made but the following species have been recognized:

LAS CAHOBES FOSSILS

LOCALITY: HILL SOUTH OF THOMONDE

Conus sp.
Cornus stenostomus Sowerby
Drilla riogurabonis Maury
Fasciolaria kempi Maury
Phos gabbi Dall
Meta perplexabilis (?) Maury
Murex domingensis Sowerby
Aspella scateroides Blainville
Strombus maoensis Maury
Turritella planigyrata Guppy
Turritella tornata Guppy
Solarium quadriseriatum Sowerby
Polinices stanislas-meenieri Maury
Sinum nolani Maury
Scapharca chiriquiensis Gabb[1]
Scapharca quayubinica Maury
Scapharca cercadica Maury
Ostrea gilbertharrisi var.[2]
Venericardia scabriocstata Guppy
Echinochama antiquata Dall
Ostrea megodon Hanley
Pecten engrammatus (?) Dall
Pecten hatoviejonis Maury
Pecten soror Gabb
Phacoides (*Mitha*) *smithwoodwardi* (?) Maury
Cardium (*Trachycardium*) *dominicanum* Dall
Tellina (*Scissula*) *cercadica* (?) Maury
Tellina cibaoica Maury
Mytilopsis domingensis Reeluz
Siliqua subaequalis Gann

[1] Occurs in massive beds.

[2] Occurs in massive beds, very much more elongated than Maury's species.

This middle division (Las Cahobes) is very thick. On the road from Hinche to Thomonde these beds are tilted to angles of from 75°–85° and the total thickness exposed is probably over 6,500 feet.

Excellent exposures of this divisions occur at many place and there are some especially interesting localities near Las Cahobes.

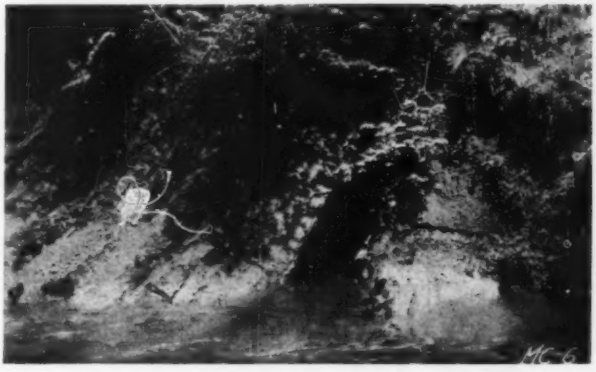


FIG. 6.—Maissade beds on Rio Blanco, showing bed of lignite

3. *Upper—Maissade Beds*

The uppermost division of this series consists of shales, marls, and some sandstones and is characterized by lignitic beds which near the town of Maissade are well defined. The division is well exposed north and west of Maissade along the Rivière Canot and its several branches, notably the Rivière Fond-de-Gras, Rio Piedre, and Rio Blanco. An excellent section is obtainable on the Rio Blanco of that part of the division containing the lignite beds (Figs. 5 and 6). Following is a detail of this locality and a list of the fossils hastily collected from it:

DETAIL SECTION ON RIO BLANCO

	FEET
Lignite, brown, flaky	6.5
Marl, gray, argillaceous	6.5
Sandstone, hard, gray	0.6
Sandstone, shaly, with masses of *Arcas* in lower part and *Ostreas* in upper part	3.5

	FEET
Clay, blue	0.6
Lignite, shaly and flaky	0.7
Sandstone, gray, lignitic streaks	5.0
Shale, with flaky lignite	3.5
Shale, gray, sandy	0.3
Clay, gray, lignitic streaks, very fossiliferous	4.5
Shale	3.3
Sandstone, fossiliferous	0.3
Lignite, shaly and flaky	1.2
Lignite	0.8
Sandstone, shaly, hard, fossils near top	0.8
Shale, black, carbonaceous	1.8
Clay, sandy, gray, fossiliferous	0.6
Clay, blue, very fossiliferous	10.5
Clay, blue, *Ostrea* bed	3.3
Clay, blue, small fossils, *Turritella*, *Ostrea* absent	4.5
Clay, blue, *Ostrea* bed with *Arcas* and other shell fragments	6.0
Clay, blue, *Turritella* bed	7.2

MAISSADE FOSSILS

LOCALITY: RIO BLANCO NORTH OF MAISSADE

Phos gabbii Dall
Melongena consors
Phos costatus Gabb
Potamides Roumaini Pillsbury[1]
Potamides caobensis Pillsbury[1]
Turritella planigyrata Guppy
Turritella tornata Guppy
Niso grandis Gabb
Scapharca chiriquiensis Gabb[2]
Scapharca cor-cupidonis Maury
Ostrea virginica Gmelin
Lucina chrysostoma Philippi
Mytilopsis domingensis Recluz

This division is particularly rich in fossils. The writer visited a locality on the Rivière L'Ayaye about twelve kilometers northwest of Las Cahobes to examine a lignite deposit. The lignite

[1] Very abundant, not noted in Maury's Santo Domingo section.

[2] Massive bed, see Fig. 5.

proved to be merely lignite fragments imbedded in sand. The exposure is a bluff on the east of the river and consists largely of shale beds dipping east at low angles. Pieces of the shale lay about the base of the bluff and from these pieces the following species were collected:

FOSSILS FROM MAISSADE BEDS ON RIVIERE L'AYAYE

Bullaria paupercula Sowerby
Terebra berlinerae Maury
Conus ritteredgei Maury
Conus symmetricus Sowerby
Conus sp.
Turris albida barretti Guppy
Turris albida virgo Lam.
Drillia fusiformis Gabb
Drillia consors Sowerby
Drillia henekeni Sowerby
Glyphostoma dentifera Gabb
Glyphostoma golfoyaquensis Maury
Oliva cylindrica Sowerby
Olivella muticoides Gabb
Marginella maoensis Maury
Marginella (*Persicula*) *cercadensis* Maury
Fusus henekeni var (?)
Mitra henekeni Sowerby
Latirus fusiformis Gabb
Vasum hiatense Sowerby
Melongena consors Sowerby
Phos costatus Gabb
Phos fasciolatus Dall
Metula cancellata Gabb
Strombina prisma P. & J.
Murex messorius Sowerby
Murex domingensis Sowerby
Murex (*Chicoreus*) *cornerectus* Guppy
Typhis cercadicus Maury
Cassis sulcifera Sowerby
Malea camura Guppy
Cypraea spurcoides Gabb
Strombus proximus
Strombina divilitus H. & M. (?)
Cerithium russelli Maury
Siliquaria gurabensis Maury

Turritella planigyrata Guppy
Natica (stigmaulax) sulcata Born
Amauropsis guppyi gurabensis Maury
Neretina (Smaragdia) viridemaris Maury
Neretina sp.
Astralium karlschmidti Maury
Callisotoma grabaui Maury
Melanella (Eulima) cercadica Maury
Dentallium dissimile Guppy
Potamides caobensis Pillsbury
Scapharca guayubinica Maury
Scapharca henekeni Maury
Scapharca (Cunearca) willardausteni Maury
Scapharca losguemadica Maury
Scapharca hispaniolana Maury
Pecten cereadica Maury
Lucina chrysostoma Philippi
Phacoides (Miltha) smithwoodwardii Maury
Cardium (Trachycardium) tintinabularum
Tellina islahispaniolae Maury
Mytilopsis domingensis Recluz
Corbula (Cuneocorbula) dominicensis Gabb
Corbula (Cuneocorbula) caimitica Maury
Euspamia sp.
Madrapore sp.

The Las Cahobes member of this series has resisted erosion to a greater extent than the members above or below it. Hence there is a generally well-defined valley or depression skirting the edge of the plain in its lower part which is underlain by beds of the lower or Thomonde division. The Las Cahobes beds stand above the general level of this plain and, where tilted, form hills parallel to its border (Fig. 7). Along the eastern and southern sides of the plain these hills are prominent and where the beds are nearly vertical sharp ridges are formed by the harder members, chiefly the conglomerates. Pine trees grow in the central plain but are confined to the areas of Las Cahobes rocks.

The foregoing notes will explain why the division of the series was made. It may not stand from a paleontologic viewpoint. It will prove useful, however, in future work and makes delineation of structure fairly simple.

Age and correlation.—On the general correlation table these sediments are shown in part as Oligocene and Miocene to correspond with Maury's determinations in the Yaqui Valley of Santo Domingo. What is here called the Maissade is undoubtedly the equivalent of the *Sconsia laevigata* and the *Aphera islacolonis* formations in Maury's section[1] and the equivalent in part of Hill's Bowden in Jamaica. This places the Maissade in the Miocene and it represents probably lower and middle Miocene. This being the case,

FIG. 7.—Hills formed by upturned Las Cahobes beds near Las Cahobes

at least the upper part of the Las Cahobes beds are the equivalent of the *Orthaulax inornatus* formation of the Yaqui section, which Maury places in the Oligocene. In general lithologic characters the beds so far correspond well to the Santo Domingo section, and while the work so far done in Haiti along paleontologic lines is merely the result of a few minutes collecting here and there, nevertheless there is a striking similarity in faunas, sufficient no doubt to make the correlation definite.

According to Gabb[2] the entire thickness of the lower members including the *Orthaulax inornatus* is only 600 feet. It seems evident that the entire section is not developed in Santo Domingo and that in Haiti the larger part of the entire thickness of sediments lies

[1] *Op. cit.* [2] *Op. cit.*, p. 95.

TABLE I

CORRELATION TABLE OF THE EOCENE, OLIGOCENE, AND MIOCENE FORMATIONS OF THE ANTILLES

Jamaica (Hill)	Cuba (Vaughan)	Santo Domingo (Maury)		Haiti (Jones)		
	La Cruz Marl	Upper horizon of Maury (*Sconsia laevigata*)		Maissade beds	Middle	Miocene
Bowden	Marl at Baracoa	Zones G, H, & I of Maury (*Aphera islacolonia*)		1,000′+	Lower	
	Anguilla	*Orthaulax* zone		Las Cahobes beds	Upper	Oligocene
(Missing)	Coral reef at Guantanamo	(Missing on north side)	Probably present under Plains of Azua and San Juan	6,500′	Middle	
	(Missing)			Thomonde beds 1,500′	Lower	
Oceanic series	St. Bartholomew limestone		(Present on south side)	Limestone series 8,000′+	Upper	Eocene

NOTE.— - - - - - indicates position of divisional line doubtful.

below anything yet described in the Antilles. Below the *Aphera islacolonis* formation of Maury we are dealing with formations which are absent in Jamaica, and below the *Orthaulax inornatus* and underlying beds of Santo Domingo we are dealing with formations which have probably not been encountered elsewhere in the Antilles.

Limestones and marls of upper Oligocene age are widespread in Cuba and only two isolated and local formations occur there which may be of early Oligocene age and both of these are doubtful.[1]

Berkey[2] places his Arecibo formation of Porto Rico as extending through Oligocene and Eocene but Maury[3] believes that it will prove to be the equivalent of the Santo Domingo section. Vaughan's[4] correlation table shows the "Pepino," of Porto Rico, equivalent to the lower horizon in Santo Domingo, which is middle Oligocene. In Jamaica, then, the middle and upper Oligocene are missing. In Cuba the upper, in Porto Rico the middle, and in Santo Domingo both upper and middle, Oligocene are present. It is thought, at least from Hill's description, that the entire Oceanic series (limestones) of Jamaica is present in Haiti. If this is true then either the lower horizon in Santo Domingo does not occupy all of middle Oligocene time or the Oceanic series of Jamaica does not extend to middle Oligocene; for in Central Haiti, between the two and forming a conformable series, is a large thickness of sediments which is apparently absent elsewhere in the Antilles.

RELATIONS OF EOCENE-EARLY OLIGOCENE LIMESTONES AND OLIGOCENE-MIOCENE SEDIMENTS

The foregoing notes will indicate a stratigraphic problem of some interest. First, in Haiti there is a thick series of sediments of Oligocene-Miocene age in which the lower and major part is confined to the Oligocene, and this part has apparently not been noted or described heretofore. Secondly, this series rests apparently

[1] Bailey Willis, "Stratigraphy of North America," *U.S. Geol. Survey, Prof. Paper 71*, 1912, p. 722.

[2] *Op. cit.*, p. 29. [3] *Op. cit.*, Bull. 30, p. 41.

[4] T. W. Vaughan, "Correlation of Tertiary Geological Formations of Southeastern United States, Central America and the West Indies," *Washington Acad. Sci., Proc.*, VIII, 1918, 268–76.

conformably on a series of deep-water limestones which extend through late Eocene and into early Oligocene. Thirdly, the Santo Domingo equivalents of the upper part of the Miocene-Oligocene series in the Yaqui Valley rest directly on the Paleozoic complex and the limestone series is lacking. Fourthly, in Jamaica there is a well-defined break in middle Oligocene time between the two. These relationships would point to an unconformable relationship between the two which in the Haiti section, since dips are concordant, would be a disconformity. The fact that the upper series is so thick below the late Oligocene, together with the fact that these beds contain no material derived from the limestone, and also from the fact that the limestones do not occur on the north side of the range, would seem to indicate that no unconformity exists in the Haiti section and that this set of conditions can be explained only in one way. The thick oceanic limestones were apparently formed against a coast off which there was an abrupt drop to deep water and this coast line lay across Haiti from southeast to northwest about on the line of the north range. The limestone would then be deposited in the form of abrupt overlap to the north. Uplift, which was sufficient to bring the limestone above the sea elsewhere, left it along this shore still below sea-level so that the later sediements (Thomonde, etc.) were laid down conformably on it. Gradual depression brought about overlap of these later sediments and the Santo Domingo section was deposited.

THE TERTIARY SERIES OF THE SOUTH PENINSULA

The foregoing notes apply chiefly to that part of Haiti north of Port-au-Prince and the Cul-de-Sac depression between the central and south ranges. The writer's observations on the south peninsula have been chiefly confined to following out in a general way Tippenhauer's sections[1] and modifying in some cases his interpretations of structure.

The probability of Cretaceous formations in this region have been previously noted. The Tertiary series is in general the same as in the northern part of Haiti but there seems to be a modification which points to a closer similarity in lithologic characters to the

[1] *Op. cit.*, Bd. 45, pp. 25–29, 201–4; Bd. 47, pp. 169–78.

Jamaican occurrences. This is not, of course, surprising in view of the fact that Jamaica is but a continuation of this peninsula.

The Eocene–Early Oligocene limestones are generally more finely bedded than in the central and north ranges of Haiti. The overlying Oligocene-Miocene series is represented in part in several localities—the L'Asile Valley and north of Aux Cayes, in both of which are found lignite deposits.

Near Jacmel on the south coast is a formation of conglomerate and marls and limestones which unconformably overlie the earlier

FIG. 8.—View of central plain of Haiti with Montagnes Noires in the distance

limestones and in the case of the conglomerates are largely composed of them. These beds are well stratified, are folded, and unconformably underlie the oldest elevated coral reefs (see Plate V, Section B). These beds may possibly be the equivalents of the Pliocene series of Jamaica (Manchioneal).[1]

LATE TERTIARY AND QUATERNARY DEPOSITS

Pliocene (?) beds of the central plain.—In the southerly part of the central plain of Haiti and resting upon the eroded edges of the Oligocene-Miocene sediments is a series of gravels and sands devoid of marine fossils. These beds, in distinction to the underlying series, contain many, and often well water-worn, bowlders of limestone (Fig. 8). Chert nodules from the foraminiferal limestones are

[1] Hill, *op. cit.*, p. 86.

very plentiful and the beds contain numerous fragments of petrified wood, often whole trunks of trees. Many of the sands are well cross-bedded. There is physiographic evidence to show that the region, after uplift and folding, drained to the southeast through Santo Domingo across what are now the plains of San Juan and Azua. Before the deposition of these non-marine beds the region suffered considerable erosion, perhaps through Pliocene time, for these beds, which the writer has called the Hinche beds, fill many old erosion gullies in the underlying folded earlier series. Drainage

FIG. 9.—South side of central plain east of Las Cahobes. Sharp hills formed by Las Cahobes beds.

was then cut off and the region became a lake in which the Hinche beds were deposited. The floor of this lake is formed by the uppermost Hinche beds and that old floor, intact in the northern part of the plain, and largely eroded away in the southern part (Fig. 8), forms the surface of the central plain above which stand the Las Cahobes beds (see Fig. 9).

Terrace deposits.—The southern part of the central plain region is terraced (see Fig. 10) and on these terraces are loose gravels. At least four terrace levels are noted. After the deposition of the Hinche lake beds an opening was cut through the limestone range south of Las Cahobes and the plain region drained that way, the rivers following the Artibonite in its lower valley. This old cut

through the high range and through the hills of Las Cahobes beds north of that place is very distinctive.

Successive uplift and periods of quiescence brought about the terracing of this region and the dissection of the plain. Erosional remnants standing as high as the old surface are numerous. Apparently only recently has the Artibonite River passed out of the plain region through the Montagnes Noires farther west.

Elevated coral reefs and marginal deposits.—The same successive elevations and periods of quiescence which brought about the

FIG. 10.—Terraces of the central plain

terracing of the central plain region has also terraced the coast, a well-known feature of the islands of the Antilles. On many of these terraces are coral reefs and marginal sands, while coral débris is common. Near St. Marc is an elevated deposit which contains innumerable specimens of *Strombus gigas*.

IGNEOUS ROCKS

SYENITE-GRANITE

The igneous rocks of Haiti present quite a range from almost a true granite to basalt. The oldest igneous rocks are the more acid, the youngest the more basic.

The oldest rocks are the syenites and granites which occupy the large areas or belts more or less parallel with the axis of the

north range and as far as noted found only in that range. These rocks are intrusive into the old complex and their age is, therefore, indeterminate. The same rocks occur in Cuba and associated with them there are serpentines. Serpentines have not been noted in Haiti. The larger masses of these syenites and granites are fairly even-grained in texture while the smaller bodies and dikes which cut the surrounding rocks in numerous places are porphyritic. As far as known no petrographic descriptions of these rocks from Haiti have been published.

There may be still older igneous members in the Paleozoic complex but the occurrence has not been noted.

QUARTZ-DIORITE

In the region north and northwest of Gonaïves are intrusions of quartz-diorite. These intrusives cut through the foraminiferal limestone series which is generally totally recrystallized along the contacts; and locally occur contact metamorphic deposits with the usual contact minerals, garnet, calcite, chalcopyrite, magnetite, pyrite, bornite, etc.

The age of the quartz-diorite intrusion is probably late Miocene and apparently took place at the time of general uplift and folding which followed the deposition of the middle Miocene sediments.

ANDESITES

Younger and cutting through the quartz-diorites are andesites. There also occur the associated andesitic flows and breccias. While these rocks are probably associated with the same general period of igneous activity as the quartz-diorites, nevertheless the flow materials often occupy erosional depressions in the underlying rocks. Andesitic rocks occupy large areas in Haiti. The intrusive phase of the rock is somewhat variable in appearance.

BASALTS

Basalts occur at several places. There are basaltic flows from probable fissure eruptions along the northern side of the salt lakes in the Cul-de-Sac depression near Port-au-Prince.

Between the Cul-de-Sac depression and Ville Bonheur (Saut d'Eau) is a well-defined crater from which extend basalt flows. These flows occupy depressions in the present topography and have not been since modified by erosion other than the removal of fine loose material leaving along the edges of the flows loose blocks of the volcanic rock resting on underlying formations. These rocks are very recent and were poured out during one of the last eruptions in Haiti.

Deposits of volcanic ash occur at numerous places, and it is said that one or more cinder cones are located near the coast on the south side of the north peninsula.

GEOLOGIC STRUCTURE

The structure sections shown herewith are composite sections based on Tippenhauer's work and the writer's observations. The profiles are only generally correct. The sections covering the south peninsula are based on Tippenhauer's mapping with certain modifications of his interpretations. While the writer has crossed this peninsula in two places his trips were very hurried and the thick vegetation prevented him from taking more than very casual notes. From the Cul-de-Sac plain north to the foothills of the north range the section is largely the writer's, especially the part covering the central plain. The several sections across the plain are the writer's and the section across the north range is somewhat imaginary, though it does illustrate conditions in that region. The last part of the section is in Santo Domingo across the Yaqui Valley and the Monti Cristi Range and is generalized. It is inserted to show the relationships of the Oligocene-Miocene formations there to the equivalent formations of the central plain of Haiti.

The structure across the central plain region shows generally sharp flexing of the Oligocene-Miocene series along the western side of the plain, while the underlying limestones are generally faulted by thrust faults of some displacement. The sharp flexures in the later sediments are doubtless faults in the limestone beneath. A large fault is indicated well up on the south range of Haiti, a well-marked depression extending east and west along the course of this fault.

The peculiar depression between the south and central ranges is apparently a normally faulted block. The structure of this block is unknown. At only one point are the underlying rocks uncovered and here what are undoubtedly Oligocene-Miocene sediments are tilted at high angles. The indications are that this plain is a region similar to the central plain of Haiti, which was down-faulted to below sea level and has only been in part lifted above the sea in Pleistocene or Recent times. This is indicated by elevated coral reefs near Port-au-Prince.

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